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ABSTRACT

The Southern Region Information Exchange Group-53 consists of 20 institutional members seeking a better understanding of the relationship between community infrastructure and economic development. This document contains four papers prepared for the group's working meeting in October 1990. "The Contribution of Four Lane Highway Investments to Employment Growth in Rural South Carolina 1970-89: Quasi-Experimentation," by M. S. Henry and others, concludes that new highways have attracted new employment opportunities to rural South Carolina. However, areas with higher growth rates, per capita incomes, and employment rates prior to highway construction benefitted most. "The Developmental Impacts of Transportational Investments," by T. G. Johnson, argues that hedonic land valuation is the only approach capable of comprehensively measuring the benefits of infrastructure investment. Using this approach within a geographic information system (GIS) is time consuming and expensive but can provide detailed projections of the location, timing, and magnitude of benefits from a great number of highway development alternatives. "GIS: A New Tool for Local Economic Development," by M. S. Henry and others, describes the use of GIS to test development policy hypotheses in South Carolina. GIS can maintain, retrieve, and manipulate spatial and nonspatial data about places, and may be used to construct hypothetical scenarios that could result from planning decisions. "Education: Linkages with Economic Development," by R. L. Clouser, reviews the research on economic development and education and finds few studies that demonstrate linkages between them. Possible research approaches are suggested. (SV)

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Rural Infrastructure and Economic Development Issues:

Information Systems, Transportation and Education

Proceedings of a Regional Workshop

Atlanta, Georgia
October 3-4, 1990

Edited by

Rod Clouser
University of Florida

Sponsored by

Southern Region Information Exchange Group-53

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Foreward

Rodney L. Clouser, Editor*
University of Florida

Welcome to the initial proceedings issue of Southern Regional Information Exchange Group 53 (SRIEG-53). The papers included in the proceedings were prepared for and presented at the exchange group's working meeting in October 1990 in Atlanta.

The common thread among SRIEG-53 members is a desire for better understanding of the relationship between economic development and community infrastructure. Infrastructure as defined by the exchange group is much broader than bricks and mortar. Community infrastructure would include human capital, education, communication, health care, etc. Anyone interested in these issues is invited to join the exchange group. For those interested in becoming a part of SRIEG-53, contact should be made with Dr. Ronald Wimberley, Department of Sociology, North Carolina State University, Raleigh, N.C. 27695-8107.

Papers prepared for these proceedings are divided into two types. Symposium papers (SP-SRIEG-53) are in-depth papers presented at SRIEG meetings in day-long workshops. Working papers (WP-SRIEG-53) are prepared for mini-workshops, typically lasting one-half day, at SRIEG-53 meetings. The intent of these mini-workshops is to discuss issues the exchange group may want to address in more detail at a future date.

SRIEG-53 members would like to express appreciation to the staff at the Southern Rural Development Center for assisting in the publication of this and future SRIEG-53 proceedings.

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Symposium Papers

The Contribution of Four Lane Highway Investments to Employment Growth in Rural South Carolina 1970-89: Quasi-experimentation

Mark S. Henry, James B. London, Kerry R. Brooks and Loretta A. Singletary*
Clemson University

INTRODUCTION

Physical infrastructure investment, particularly transportation innovations, set the cornerstone for socio-economic change in the United States. The construction of navigable water routes, then railways, and later roads, highways, and the interstate system nurtured a perception of a causal role between transportation and economic growth. Increased access, it was commonly theorized, would stimulate growth in manufacturing and commercial activity. Disciples of central place, classical location, or, later, "growth pole" theory maintained that industry would seek, presumably, locational advantages revealed by major highway improvement schemes (Losch, 1938; Weber, 1929; Moses, 1958; Alonso, 1964). Early efforts by Zipf (1949) and others (Niedercorn and Bechhdolt, Jr., 1969) to derive a regional law of gravity for development initiated a genre of research on transportation and economic development potential.

Early statistical analyses (generally simple regression, rank correlation or descriptive, i.e., survey data) attempted to estimate economic growth primarily as related to changes in population and land use based on proximity to highways. Twark (1967) discovered, for example, that daily traffic on a cross-route, on the interstate highway, and some population measure were positively correlated with new development at interchanges. Likewise, economic development at the interchange was inversely related to distance from the nearest urban center.

EMERGING DOUBTS

As the interstate highway system neared completion and post construction data became available, evidence for assured blanket growth, as presumed earlier, became increasingly less evident. Enactment of the Appalachian Regional Development Act of 1965, to promote economic growth and raise living standards, generated contradictory studies and results.

Munro (1966) and Straszheim (1972), for example, criticized the Appalachian (ARC) highway investment program for its lack of investigative detail in the planning phase. They surmised that it was an efficiency-criterion program rather than redistributive as was intended. Admittedly, highway construction might have interregional effects, but even so, Munro questioned, were the existing highways so inefficient as to justify highway investment as a development strategy? Strasheim added that ARC highway expenditures would be more likely to encourage outmigration. Additionally, Hale and Walters (1974) determined that greater benefits in transportation and employment would be felt in the periphery or secondary growth centers of Appalachia and regional outmigration would be the end result. Hansen (1966) decried

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the policy for its neglect of opportunity cost and labor mobility issues. Short-run investment, he argued, should be allocated to social overhead capital (education and health care) with longer-run emphasis on a combination of social and economic (highway) investment.

Similarly, Kuehn and West (1971) in their analysis of the Ozarks Economic Development Region concluded that highways are only "permissive causes of regional development insofar as they primarily affect regional supply conditions." In fact, highways, they contended, probably serve to encourage initial growth in employment and income which induce additional highway construction. Rank correlation coefficients indicated that they were not crucial factors in economic development in the Ozark Region.

Cribbins, et al., (1965) finding insignificant regression coefficients for highway associated land value changes, simply deduced:

> The major effects of [interstate highway] construction will be gradual and intermixed with the effects of other factors controlling an area's economic development. If the economy of an area is basically sound and is growing, then it will continue to grow; if it is basically depressed, then it will remain depressed.

EVOLVING THEORY AND METHODOLOGY

Academic literature, subsequently, criticized measurement techniques as lacking sophistication. Social scientists called for the innovation of precisely defined appraisal schemes based upon more theoretically grounded methodology. The call inspired researchers to ask different questions. Specifically, there surfaced a need to clarify what constituted benefits (primary or "direct" and secondary or "indirect") of highway investment. Conventional cost-benefit analyses concentrated on direct user benefits exclusively. This translated loosely (but acceptably) to increases in user savings in terms of travel time, vehicle operating costs, and accidents in pre and post highway conditions. These savings were compared to capital cost of the highway to establish rankings of investments in benefit-cost terms (Gruver, 1974).

It was argued additionally that user benefits "include all the real benefits resulting from a project or that any indirect effects bear some constant relation to user benefits so that ranking would be unaffected by their explicit consideration" (Gwilliam, 1970). The contention, however, was that if abnormally large indirect effects occurred in the form of "reorganization of economic structure" then conventional techniques would rank highway projects incorrectly. In other words, over or under-estimation could occur.

More recently, Johnson (1990) emphasized the distinction between impact analyses (distributional in nature) and net benefit analysis (efficiency concerns). Moreover, he carefully lays out the case for use of land markets as a way to measure net benefits of a transportation project. The idea is simply that land markets will capitalize the value of transport improvements and so pre and post project land prices will be the appropriate measure of net project benefits. Citing work by Kanemoto (1988) regarding the general equilibrium view of net benefit estimates using hedonic land prices, Johnson concludes that even with departure from many of the assumptions underlying the use of land markets for benefit estimate, hedonic land value models are appropriate for estimating the net benefits of transport improvements.

Aschauer (1990) provides a simple economic framework for estimating the direction of causality from highway investment to economic growth at the state level. He finds that over the 1960 to 1985 period, added road capacity (miles of highway per square mile in the state) leads to added growth in per capita income. Moreover, increased rural road capacity tends to have a larger impact on growth rates than urban roads. At a more micro level, Fox and Murray (1990) use a Tobit model of firm location in Tennessee counties. They find that the presence of in-county interstate highways leads to higher entry rates into those counties for most size of firm categories-- but they do not directly test for

the direction of causality between highways and firm location. While Aschauer's results support a conclusion of a direction of causality from highways to growth at the state level, his results are not adequate at the micro level. And, while Fox and Murray have a sound empirical base for testing at the micro level, they do not provide a direct test of the direction of causality. At this juncture, we turn to some alternatives to traditional econometric models and to a focus on rural areas.

GEOGRAPHIC FOCUS: NONURBAN

Geographic specific questions include whether highway investment produces booming interchange communities in nonurban locales or rejuvenates entire lagging rural regions. The exact approaches and findings remain varied, however. Additionally much of the Interstate highway system is located in rural or nonurban areas not served previously by major highways. Such a major highway construction project has carried with it expectations for major impacts on socioeconomic variables of communities with these Interstate "corridors." This would be true particularly for communities with interchanges linking interstate highways with local transportation networks (Eyerly, et al., 1987). An analytical consensus, however, is lacking in that research on highway investment produces no guarantee of promoting positive changes even in such geographic specific contexts.

Miller (1979) observes that no empirical evidence indicates that nonmetropolitan counties with Interstates experience persistent expansion of job opportunities. Instead, he finds that these counties experienced growth in the late 1960s which diminished after the completion of the Interstate system in the 1970s.

Additionally, Humphrey and Sell (1975), find that impact of highways is secondary to other correlates of nonmetropolitan growth. Multiple regression analyses to determine a relationship between characteristics of nonmetropolitan communities and the average annual rate of demographic growth produce no statistically significant relationship between distance to controlled access highway interchange and nonmetropolitan growth between 1940 and 1950. Although, between 1950 and 1960, and from 1960 to 1970, minor civil divisions with close proximity to interchanges exhibit significantly higher growth rates than places farther away. Population density of nonmetro places and distance to metro centers are both negatively related to population growth. Outmigration is apparent in minor civil divisions (MCD'S) with substantial populations of 15-24 years of age persons. Population size of an MCD did not produce statistically significant overall relationship to growth between 1940 and 1970.

Lichter and Fuguitt (1986) study three time periods (1950-75). They find that positive effects of highways on net migration is most pronounced in less remote areas and that it promotes employment change in nonlocal and tourist-related service employment. There exists, however, little proof that highways influence demographic changes through expanded manufacturing or increased employment to promote inmigration.

Briggs (1980, 1981, 1983) examines factors involved in demographic and economic change in nonmetropolitan areas of the US from 1950 to 1975. He compares with and without interstate counties for changes in net migration and employment and identifies types of industries affected by limited access highways using path analysis. Results indicate existence of a weak relationship only. Manufacturing and wholesaling have minor roles with correlation coefficients of .04 and .02 between 1960 and 1970 and .005 and -.02 between 1970 and 1975. "Tourist services, however, is the industry most closely associated with interstates with correlation coefficients of .07 and .03, respectively." Using a series of multiple regression models, Briggs analyzes the importance of transportation after controlling for metro area adjacency and urban population concentration. Interstates do not, according to Briggs' results, ensure growth for an individual county. In fact, nontransportation factors explain spatial development patterns of development better than interstates. These include urbanization, industrial base, social base, government activities, and environmental

amenities. These, however, produce consistently small correlation coefficients and beta weights as well. He concludes that manufacturing may benefit from highways but may not necessarily have to locate near them whereas tourism requires physical proximity to highways.

More recently Stephanedes and Eagle (1986) investigate interaction between employment and transportation, using cross-sectional analysis of 30 Minnesota nonmetro counties over a 25-year period. Mixed results are derived from causality tests in that highway expenditures affect manufacturing and retail employment and employment then affects highway expenditures. But for counties located more than 25 miles from large cities (>30,000) causality is not evident. In the short run, employment increases after highway improvements. But by the 10th year, employment returns to the initial base as improved access to metro areas draws employees away. This is especially true for those counties within 25 miles of a large city.

Contrary to this conclusion, however, are the findings of Burress and Clifford (1989) who contend that Interstate highways improvement likely encourages private sector growth but with a several year lag. There are however, no significant short-run multiplier effects. Non-local government activities such as higher education and transfer payments may have more immediate multiplier effects on local economy. Specifically they examine the roles of higher education, interstates, and transfer payments in growth of income, population, and employment in Kansas counties between 1969 and 1985. Thus, they look at direct multiplier effect of government activity and indirect effect of government services in expanding the private sector.

Moon (1987) studies nonurban interchange "villages" to understand a pattern of cyclical development in their evolution. His investigation suggests that these "interchange villages" act as central places within their regions. Typically these "new" towns function as tourism service centers, island communities of other urban areas, or focal points of regions.

Eyerly, et al., (1987) examine the interchange growth hypothesis via use of conventional indices (income, housing, population, employment) and new indices ("assessed market value of real property"). Regressing county level changes in per capita income on these variables indicate a positive relationship with nonurban interchanges.

Barkley, et al.(1988) examine the interaction between rural transportation with high technology economic development. Attempts are made to determine its relative importance as a locational factor. They argue that transportation factors have been ignored due to assumption that high tech industries are predominantly labor and amenity oriented (i.e., the early assumptions with transportation and industrial location were based on increased access to raw material and market centers). It is suggested that understanding interaction between high technology development and transportation involves a grasp of alternative perspectives from which to analyze it. These include industrial organization (i.e., that is, examining agglomeration phenomenon like the clustering of small firms that network to reduce risks). Additionally, spatial diffusion of firm functions based upon improved air travel and communication systems, they assert, needs to be addressed. Finally, the social organization of a local economy and local institutional arrangements are important in developing a climate conducive to attracting high technology firms.

Nijkamp (1982, 1985, 1986) attempts to arrive at some theoretical understanding of recent research findings. Nijkamp analyzes production and potentiality factors to identify disparities among regions with approximately equal private stock. He concludes that both network and urban infrastructure provide a significant explanation for regional development asserting that it is the stage of total socioeconomic development in an area or region that determines the effects of infrastructure investment. It cannot be deduced from research that infrastructure investment will lead a priori to regional development improvement. This implies that infrastructure policy is only a conditional policy dependent upon a number of regional socioeconomic elements.

Wilson, et al., (1985) attributes weak

empirical relationships between regional economic growth and highways to "saturation and shift." That is, the highway system becomes saturated with increase in mileage, and developmental effects become progressively diluted. New highways at some point act only as people movers. Wilson maintains that the phase of highway development is an important factor, i.e., in the first phase it encourages regional development whereas in the third phase it induces personal mobility. Notably, Baerwald (1982) cites historical factors and the timing of development as an important factor in development process. And, Eyerly reminds us that early studies were predictive in nature in this respect, as the research was conducted while highways were under construction or immediately thereafter.

Isserman (and Isserman, et al., 1982, 1987 1989) developed an approach to the issue using a control group research design. Assessing the effectiveness of highways in spawning growth requires the consideration of conditions such as where it is, what it connects, and what it is near, to name a few. Noting that earlier research attempted some facsimile of quasi-experimental procedure (Wheat, 1970), Isserman's studies indicate that although there are benefits associated with linking a city and its county to the Interstate system, no significant effect on income in "rural links" results after the construction phase.

QUASI-EXPERIMENTAL METHODOLOGY

Traditional experimental research design, used frequently in psychology, education, political science, sociology, in addition to other behavioral sciences, requires random selection of groups, one or more of which are subject to a "treatment" or the event under analysis. Groups not receiving the treatment are analyzed to account for changes that occur and are "controlled" for exogenous factors that might influence the outcome of the experiment. The basic concept is that "without a control group there is no way to tell how much of the overall effect in the experimental group was true cause and how much was exogenously induced" (Campbell and Stanley, 1963).

Quasi-experimentation allows for the absence of this random selection of subjects. Isserman's application of quasi-experimentation to measure economic impact of regional policy modifies parametric quasi-experimental techniques utilizing a "separate-sample pre-test/post-test control group design." Basically, this requires the selection of control groups based upon a set of predetermined criteria. The premise of the comparative analysis is to designate a control group whose experiences form a baseline against which to infer the effects of the treatment. In this case, highway improvements are the treatment. The role of the control group is to control for those things that occurred during the analysis period and then to distinguish between what would have happened without the highway from what did happen with it. The difference equals the impact of the highway. Impact on a single sector's employment, for example, may be calculated with the following equation:

$$I_{ht} = Y_{ht} - r_{hc} Y_{ho} = (r_{ht} - r_{hc}) Y_{ho},$$

I_{ht} = employment changes from period o to t attributed to the highway treatment h;

Y_{ht} = employment in the treated region in year t,

Y_{ho} = employment in the treated region in year o - prior to treatment,

r_{hc} = growth rate of employment in the control region from o to t,

r_{ht} = growth rate of employment in the treated region from o to t,

Total employment impacts are determined by summing over sector specific impacts.

RESULTS FOR RURAL SOUTH CAROLINA

The work discussed in this section relies on the quasi-experimental method, and a combination of Census and Dun and Bradstreet data that is geocoded using ARCINFO as GIS software. Other work in progress includes econometric estimation along the lines of Aschauer (1990) and Fox and Murray (1990).

Two sets of estimates of the impact of new four lane highway investment on local development in South Carolina are considered. First, employment change by county census division(CCD) from 1970 to 1980 is examined. Next, employment change during the period from 1980 to 1989 is considered using a set of "Z" regions that are formed by overlaying zip code and CCD regional boundaries.

Data Issues

The reason for this mix of regional definitions is data limitations. Briefly, 1990 CCD data are not yet available from the Census--precluding their use for the 1980-1990 period. Second, Dun and Bradstreet data by firm may be allocated to zip and CCD's yet the files available to our project include the some 60,000 firms that are current survivors over this period. Firms that were established and have perished during the 1970-89 period are not available. This is a disadvantage since we lose the information about firms that were born and died in the period. Thus, we are only able to track the behavior of the long term survivors--those firms that have had the longest lasting impact on areal employment. And, since we consider cross sectional observations on the performance of the "Z" regions, the bias in our results emanates from any systematic differences across regions in firm birth and death activity.

By controlling for initial conditions in each region for degree of rurality and beginning of the period socioeconomic conditions, the control group method should "capture" this systematic bias. For example, we compare a cross section of 50 isolated rural regions drawn from the same population prior to a highway treatment. Thus, these regions should have similar patterns of births and deaths of firms. Looking at the change in surviving firms in a subsequent period in which some of these regions are treated with highways and some are not assumes that the presence of highways in selected regions does not disturb the birth/death pattern in these regions. In fact, one might expect the presence of a highway to generate both more births and deaths as well as added survivors all else the same. In the nontreated regions, there is no reason to expect a change in the birth/death pattern as a consequence of other regions being treated, if all the regions are independent observations drawn from the same pre-treatment population.

By looking at survivors only, we take a long-run impact perspective. Firms that were formed in the 1970s and are still active in 1990 represent long-run impacts. Firms that were formed in the early 1980s and are still active may be expected to contain a larger share of firms that will die over the next five years than from the group of firms formed in the 1970s. Or, the 1980s formations may reflect newer technology and be more in tune with consumer trends. Empirical answers to these questions is beyond the scope of this paper. For our purposes, it is adequate to look only at survivors. We lose the information on the effect that new highways may have on short run births and deaths of firms in a region. We suspect that these transitory events are concentrated in the trade and service sectors where the death of one firm may be a signal to another entrepreneur to capture the market share lost by the dying firm.

Clusters, Highway Treatments and Mean CCD Growth Differences, 1970-1980

Because 1970 socioeconomic conditions in each region suggest the "stage of development" of a region(CCD) and thus affect the potential impact that a new highway may have on employment(Nijkamp), we use 1970 Census data to characterize these regions in two dimensions. First, a measure of 1970 per capita income, INCR70, is constructed from Census data by CCD for South Carolina. Second, a measure of the utilization of the local labor force is constructed, EMPR70, which is the ratio of

employed persons to labor force age population in each CCD. A simple cluster analysis is performed on these two dimensions of the "stage of local development." The result is a set of four clusters summarized in Table 1. A plot of the clusters is shown in Figure 1.

Cluster 3 may be characterized as the high income/high employment rate CCDs-- those with the most advanced development as of 1970. In contrast, CCDs in cluster 4 may be at the other end of the spectrum with low incomes/low employment rates. These CCDs would seem least likely to be able to take advantage of highway improvements if other "pre-conditions" are lacking.

Clusters 1 and 2 are the most numerous and provide a set of regions that were--by these measures-- in some sort of intermediate stage of development. Cluster 1 appears to represent the CCDs that are closest to the elites of cluster 3 while cluster 2 has substantially lower incomes and somewhat lower employment rates than in cluster 1. In sum, cluster 3 is the "high" class, cluster 1 is the "upper middle" class, cluster 2 is the "lower middle" class, while cluster 4 is the "low" class set of CCDs in 1970 in terms of socioeconomic development.

One might expect that if beginning stage of development matters, the high group would benefit from new four lane highways. As a way to test these assertions, we have identified the highway treatment by decade in each of these CCDs. If a CCD-- in any cluster-- were first "treated" by a four lane highway in the 1960s, we view this as establishing a pre-condition for growth during the 1970-1980 period. If the first highway expansion were during the 1970s, then we view this as a combination of accommodation and pre condition to growth during the 1970s. Finally, first highway investment during the 1980s would, by definition, have to be viewed as accommodating to growth of the 1970s.

In terms of cause and effect, the most direct test of the impact of highway expansions is to consider those CCDs within the same cluster that were treated with a four lane highway prior to 1970 and those that were not treated. Significant differences in mean growth rates of employment change from 1970 to 1980 between treated and nontreated regions support the notion of highway additions "causing" added employment in the sense of being one of the necessary conditions for growth to occur. And, we might expect that some regions will benefit more than others to the extent that the other necessary conditions for growth exist and simply lack adequate transportation access. These "middle class" regions in or context are CCDs in clusters 1 and 2. Cluster 3 CCDs grew faster than other regions prior to 1970 and perhaps have less added growth potential than the middle class regions. Finally, the poor CCDs in cluster 4 do not seem to have acquired the other preconditions for growth and we would expect little change in these regions from new four lane highways.

We look only at the CCDs outside the MSA counties of 1970 to avoid comparing rural areas with the urban complexes in South Carolina.

Results

To reiterate, we compute employment growth from 1970 to 1980 in each CCD. Then we identify each CCD by its initial "stage of development" through the cluster analysis. Finally, we select CCDs with four lane highways built during the 1960s period and compare growth rates between control and these "treated CCDs" in rural South Carolina. We repeat the process for CCDs whose first four lane was built during the 1970s and for CCDs whose first four lane was built during the 1980s. The comparisons are made after sorting CCDs in Metropolitan Statistical Area (urban) and non-MSA (rural) categories. Results of the total employment growth rate comparisons and the companion t tests are shown in Tables 2 and 3.

CCDs Treated Prior to the 1970s Versus Control CCDs.

In Table 2A, rural CCDs that were treated first in the 1960s are considered. Results for clusters 1 and 2, the middle class CCDs, indicate treated CCDs grew faster in the 1970s than the control CCDs. In cluster 1 treated CCDs grew 31 percentage points faster than control CCDs and 24 percentage points faster in cluster 2. These differences are statistically

significant at commonly accepted levels of making a type 1 error.

While there are only 10 CCDs (out of 294 CCDs in the state) that are rural and fit the "high" category of CCDs, there is a 61 percentage point growth rate advantage in the treated regions though the t test does not support this conclusion. At the other extreme, in the low category of CCDs only 1 out of 16 Rural CCDs was treated with a four accommodate growth forces already in action. The low group might lack the other conditions needed to make highway investment sufficient for employment growth, but the middle class groups would seem to be sufficiently advanced to benefit from new four lane highways -- with the upper middle group best positioned to benefit from the new highways. In sum, the comparison of employment growth rates during the 1970s suggests that rural CCDs that were treated with a four lane highway during the prior decade did in fact grow faster than their non treated counterpart--controlling for beginning period socioeconomic conditions.

CCDs Treated During the 1970s Versus Control Regions

The results of comparing CCDs that were never treated with those that received their first treatment in the 1970s stand in stark contrast to those of the 1960s treatment results. As shown in Table 2B, almost all of the mean growth differences are smaller and none are statistically significant except for rural cluster 4--the poorest places as of 1970. In cluster 4 the nontreated CCDs grew some 24 percentage points faster than in the treated CCDs.

These results taken in tandem with the evidence from the 1960s comparisons suggest that there is a an important lag between four lane expansions and subsequent economic growth. This is consistent with the finding at the county level for Kansas by Burress and Clifford (1988). There may be something unique about the 1960s efforts in the sense that the interstate system was complete enough to generate some kind of one time boost to all places. If so, added four lane access might be expected to have less marginal effect after the 1960s.

The rapid growth of the national economy during the late 1960s may also be contributing to higher overall growth rates in the 1960s. Finally, the brief "rural turnaround" of early 1970s with net migrant flows to rural areas for retirement, and general vibrancy of rural sectors during this period-- textile employment and farm income were at very high historical levels during much of the 1970s-- may be contributing to the cluster 4 results seen in South Carolina.

CCDs Treated During the 1980s Versus Control Regions

For CCDs that were first treated with four lane highways after the growth of the 1970s, results in Table 2C show that the rural CCDs in clusters 1 and 2 had higher growth rates in the 1970s-- with significant differences only in cluster 2. This simply suggests that those rural CCDs-- within the same beginning period "stage of development" cluster and that grew faster in the 1970s were able to obtain added four lane service to accommodate growth.

Results for Urban CCDs

It is also interesting to note that the urban CCD comparisons suggest that highway treatment matters but perhaps less convincingly. In Table 3 the tests for urban clusters 1 and 2 suggest that at commonly used significance levels there is no significant difference in growth rates. For cluster 3, comparisons are not possible within the urban CCD group. However, the average growth rate for the treated areas was 1.469 in urban CCDs versus 1.78 for treated rural CCDs in cluster 3. This suggests that rural high CCDs benefited from the new four lane highways relative to their high urban counterparts.

Clusters, Highway Treatments and "Z" Region Growth Differences: 1970-1989

While the results for the CCD comparisons support the idea that highways matter to employment growth, additional evidence gained from alternative methodological procedures is

needed to examine the robustness of this conclusion and to define the conditions under which added four lane highways matter to regional growth. The second step we have undertaken in pursuit of these goals is to turn to greater geographical detail and to use firm level data on location patterns in the state.

With respect to geographic detail, we use ARCINFO procedures to overlay four digit zip code boundaries with the CCD geography. This results in 477 unique "Z" regions that are intersections of zip and CCD areas (see Figure 2). At this juncture, we allocate some 60,000 firms in the 1989 Dun and Bradstreet files for South Carolina to each of these regions. We have some 3000 manufacturing firms geocoded, using ARCINFO from the South Carolina Industrial Directory(SCID) for 1989. Finally, all Dun and Bradstreet firms-- not in the SCID files-- that exceed 25 employees are point located, using digitizing procedures in ARCINFO.

Using GIS techniques, a 5km buffer is drawn around each new four lane highway segment completed from 1960 through 1989. The Z regions that are touched by this 5km buffer are assumed to be the regions directly affected by the transport improvements that are provided by the new four lane highway. These Z regions are the treated regions in the context of the quasi-experimental technique. Other Z regions that were in the same 1970 "stage of development" cluster are the control regions. Regions may be treated more than once during the period.

To test for mean differences in employment change using the Z regions and the firm level data, we use analysis of variance. We construct through dummy variables a set of categories of treatment intensity. These are highways built in the 5km buffer region during the 1960s only, 1970s only, 1980s only, 1960s and 70s, 1970s and 80s, 1960s and 80s, and 1960s 70s and 80s.

We focus on employment growth during the 1980s by holding constant the level of employment in firms established by 1979 and looking at employment in firms that were established during the 1980s. Holding constant the size of the regions in square kilometers, ZAREA, the results for all Z regions are shown in Table 4.

Table 4A contains the results for nonmanufacturing firms with more than 25 employees. The dummy variables are structured to exclude the lowest cluster regions(cluster 4 from the previous section) and the Z regions never treated with a four lane highway. The ET67 variable represents employment in firms established prior to 1980 to control for agglomeration forces. It is significant and suggests that Z regions with 1000 more employees in firms established by 1979 than the mean region would garner some 110 added employees in firms established during the 1980s -- all else the same.

Each of the highway dummy variables has a positive sign and all but D70 (four lane projects only in the 1970s) and D78 (four lane projects in the 1970s and 1980s) appear to be statistically significant at reasonable probabilities of making a type 1 error. Finally, the "stage of development" dummies suggest that those that were best off in 1970 fared better than the middle and lower class regions. The cluster 3 regions tended to have 195 more employees added by firms established during the 1980s than the cluster 4 --low group--counterparts, ceteris paribus. Table 4B contains the results for large manufacturing firms--those with more than 100 employees by 1989. Here, strong agglomeration effects seem apparent and all highway dummies are positive except the D78 period, which as an insignificant negative sign. Initial stage of development dummies again suggest that the "rich get richer" in terms of large manufacturing firms locating in cluster 3 regions such that these regions gained about 304 more employees in firms established in the 1980s than the poor counterparts in cluster 4.

Table 4C lists the results for the small manufacturing firsm--those withe fewer than 100 employees. Again, agglomeration effects are important and all highway dummies except the D78 period (statistically not significant) indicate positive effects. However, only the D60, the 1960s only, and the D678, projects in the 60s, 70s and 80s suggest a strong effect from new four lanes to small manufacturing firm growth in the 1980s. The HIGH, MIDHI and MIDLOW dummies all have negative signs indicating that the poor CCDs may be gaining in the small

manufacturing sector--especially if they had been treated with a four lane highway in the 1960s.

CONCLUSIONS

The quasi-experimental tests suggest that there are strong effects of new four lane highways on the ability of rural areas to attract new employment opportunities to their part of South Carolina. Some places are better situated to take advantage of the highway additions than others. It appears that regions that grew faster in the past and accumulated some agglomeration advantages and those that had higher per capita incomes and employment rates continue to benefit most-- in terms of added employment in new firms-- as highway investments are made.

Statistical issues remain and data improvements are needed prior to estimation of more formal econometric models of firm location and regional growth, but, it would be surprising in light of the results to date if we find that highways don't matter. We suspect that transportation improvements in rural South Carolina will benefit only a subset of all rural areas-- those that have the other "pre-conditions for growth" in place. Remaining rural areas may need to turn to an alternative development agenda.

Finally, we are in the process of developing a continuous measure of Z region rurality using GIS. This involves creating a simulation of the networks of four lane roads in S.C. and calculating the time required for firms located in the centroid of each Z regions to travel to the nearest central city Z region by way of the four lane network. The more isolated (and rural in our view) that a Z region is from these urban centers of the state, the greater is the "friction" of distance and lower the level of transport services available to them. Investment in new four lane connections over time may be simulated and reductions in travel time estimated for each of the Z regions. So, we compute the travel times to urban centers given the four lane system in place by 1970. Next, we add the new four lanes to the system in the 1970s--then in the 1980s-- and recompute the travel times. This process gives us both an initial period (1970) perspective on regional isolation and a view as to how the new four lanes have changed the level of isolation or rurality over time.

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Table 1.

CCD Clusters for 1970 - South Carolina

Cluster Means				Cluster Standard Deviations	
CLUSTER	N	$ INCR70	EMPR70	$ INCR70	EMPR70
1	124	3483	0.595	279	0.035
2	116	2672	0.533	257	0.054
3	22	4340	0.615	243	0.029
4	31	1871	0.448	212	0.079

INCR70 - Per Capita Income, 1970.

EMP70 - Employment/Labor Force Population, 1970.

FIGURE 1.

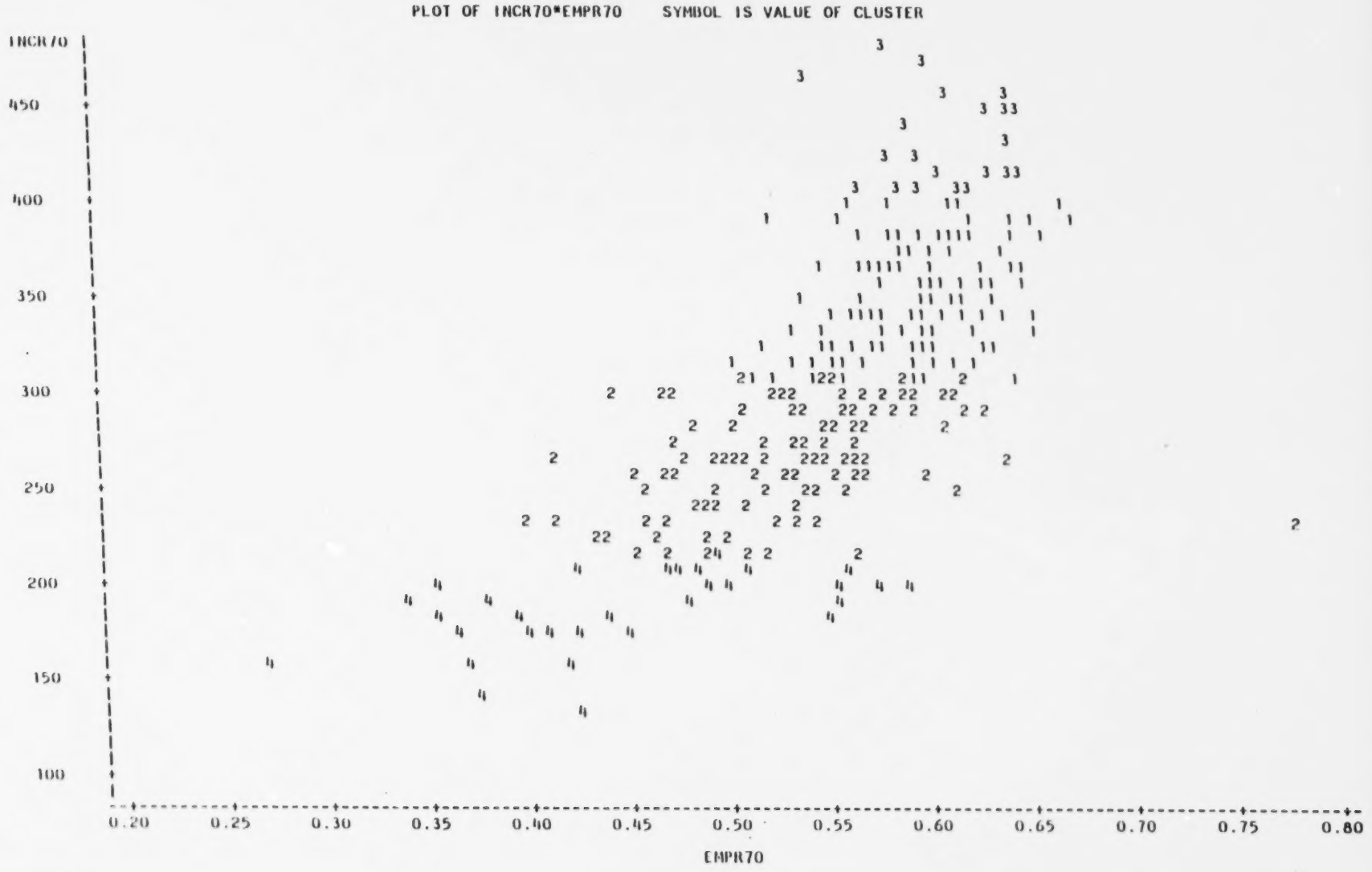
PLOT OF INCR70*EMPR70 SYMBOL IS VALUE OF CLUSTER
INCR70
450
400
350
300
250
200
150
100
0.20
0.25
0.30
0.35
0.40
0.45
0.50
0.55
0.60
0.65
0.70
0.75
0.80
EMPR70

TABLE 2A
HIGHWAY TREATMENT IN 1960S
MEAN EMPLOYMENT GROWTH 1970-1980 FOR S.C. COUNTY CENSUS DIVISIONS - RURAL GROUP

RURAL--CLUSTER 1 - Upper Middle
VARIABLE: EMPGROW

CLASSGO	N	MEAN	STD DEV	STD ERROR	MINIMUM	MAXIMUM	VARIANCES	T	DF	PROB > |T|
Control 0	33	1.20329647	0.34844733	0.06065689	0.09792368	1.90953545	UNEQUAL	-2.4569	65.0	0.0167
Treated 1	44	1.51190584	0.72960560	0.10999218	0.39027087	4.70916609	EQUAL	-2.2429	75.0	0.0279

FOR HO: VARIANCES ARE EQUAL, F'= 4.38 WITH 43 AND 32 DF PROB > F'= 0.0001

RURAL--CLUSTER 2- Lower Middle
VARIABLE: EMPGROW

CLASSGO	N	MEAN	STD DEV	STD ERROR	MINIMUM	MAXIMUM	VARIANCES	T	DF	PROB > |T|
Control 0	51	1.14610206	0.34453135	0.04824404	0.44852071	2.24680851	UNEQUAL	-2.0263	34.4	0.0505
Treated 1	25	1.38081660	0.52653142	0.10530628	0.93400713	3.39677744	EQUAL	-2.3308	74.0	0.0225

FOR HO: VARIANCES ARE EQUAL, F'= 2.34 WITH 24 AND 50 DF PROB > F'= 0.0115

RURAL -- CLUSTER 3 - High
VARIABLE: EMPGROW

CLASSGO	N	MEAN	STD DEV	STD ERROR	MINIMUM	MAXIMUM	VARIANCES	T	DF	PROB > |T|
Control 0	2	1.17207969	0.20792617	0.14702600	1.02505369	1.31910569	UNEQUAL	-2.0104	7.2	0.0835
Treated 1	8	1.77717416	0.74281122	0.26262343	1.20753084	3.46924779	EQUAL	-1.0954	8.0	0.3052

FOR HO: VARIANCES ARE EQUAL, F'= 12.76 WITH 7 AND 1 DF PROB > F'= 0.4247

RURAL -- CLUSTER 4 - Low
VARIABLE: EMPGROW

CLASSGO	N	MEAN	STD DEV	STD ERROR	MINIMUM	MAXIMUM	VARIANCES	T	DF	PROB > |T|
Control 0	15	1.34899539	0.31376844	0.08101466	0.86453202	2.00198807	UNEQUAL			
Treated 1	1	1.11255411	.	.	1.11255411	1.11255411	EQUAL	0.7296	14.0	0.4777

NOTE: ALL VALUES ARE THE SAME FOR ONE CLASS LEVEL.

TABLE 2B
HIGHWAY TREATMENT IN THE 1970S - RURAL GROUP

RURAL CLUSTER 1 - Upper Middle
VARIABLE: EMPGROW

CLASS/O	N	MEAN	STD DEV	STD ERROR	MINIMUM	MAXIMUM	VARIANCES	T	DF	PROB > |T|
Control 0	33	1.20329647	0.34844733	0.06065689	0.09792368	1.90953545	UNEQUAL	-0.7058	9.0	0.4981
Treated 1	8	1.32622438	0.46174546	0.16325167	0.79595376	2.23843188	EQUAL	-0.8400	39.0	0.4060

FOR HO: VARIANCES ARE EQUAL, F'= 1.76 WITH 7 AND 32 DF PROB > F'= 0.2623

RURAL CLUSTER 2 - Lower Middle
VARIABLE: EMPGROW

CLASS/O	N	MEAN	STD DEV	STD ERROR	MINIMUM	MAXIMUM	VARIANCES	T	DF	PROB > |T|
Control 0	51	1.14610206	0.34453135	0.04824404	0.44852071	2.24680851	UNEQUAL	-1.3041	37.0	0.2002
Treated 1	23	1.27276639	0.40427624	0.08429742	0.23076923	2.05501618	EQUAL	-1.3861	72.0	0.1700

FOR HO: VARIANCES ARE EQUAL, F'= 1.38 WITH 22 AND 50 DF PROB > F'= 0.3466

RURAL CLUSTER 3 - High
VARIABLE: EMPGROW

CLASS/O	N	MEAN	STD DEV	STD ERROR	MINIMUM	MAXIMUM	VARIANCES	T	DF	PROB > |T|
Control 0	2	1.17207969	0.20792617	0.14702600	1.02505369	1.31910569	UNEQUAL	-0.9050	1.3	0.5088
Treated 1	2	1.52406823	0.50919535	0.36005549	1.16401274	1.88412371	EQUAL	-0.9050	2.0	0.4610

FOR HO: VARIANCES ARE EQUAL, F'= 6.00 WITH 1 AND 1 DF PROB > F'= 0.4936

RURAL CLUSTER 4 - Low
VARIABLE: EMPGROW

CLASS/O	N	MEAN	STD DEV	STD ERROR	MINIMUM	MAXIMUM	VARIANCES	T	DF	PROB > |T|
Control 0	15	1.34899539	0.31376844	0.08101466	0.86453202	2.00198807	UNEQUAL	2.2763	25.0	0.0317
Treated 1	12	1.10454797	0.24419178	0.07049210	0.74137931	1.62796504	EQUAL	2.2126	25.0	0.0363

FOR HO: VARIANCES ARE EQUAL, F'= 1.65 WITH 14 AND 11 DF PROB > F'= 0.4084

TABLE 2C
HIGHWAY TREATMENT IN THE 1980S - RURAL GROUP

RURAL CLUSTER 1- Upper Middle
VARIABLE: EMPGROW

CLASS80	N	MEAN	STD DEV	STD ERROR	MINIMUM	MAXIMUM	VARIANCES	T	DF	PROB > |T|
Control 0	33	1.20329647	0.34844733	0.06065689	0.09792368	1.90953545	UNEQUAL	-0.8397	5.0	0.4392
Treated 1	5	1.35690657	0.38593657	0.17259608	0.99579169	1.94674013	EQUAL	-0.9073	36.0	0.3703

FOR HO: VARIANCES ARE EQUAL, F'= 1.23 WITH 4 AND 32 DF PROB > F'= 0.6381

RURAL CLUSTER 2 - Lower Middle
VARIABLE: EMPGROW

CLASS80	N	MEAN	STD DEV	STD ERROR	MINIMUM	MAXIMUM	VARIANCES	T	DF	PROB > |T|
Control 0	51	1.14610206	0.34453135	0.04824404	0.44852071	2.24680851	UNEQUAL	-1.8553	12.5	0.0873
Treated 1	9	1.34386692	0.28515343	0.09505114	0.92684866	1.96139360	EQUAL	-1.6233	58.0	0.1100

FOR HO: VARIANCES ARE EQUAL, F'= 1.46 WITH 50 AND 8 DF PROB > F'= 0.5949

CLASS60 = 1: First four-lane highway expansions in the 1960s.
CLASS70 = 1: First four-lane highway expansions in the 1970s.
CLASS80 = 1: First four-lane highway expansions in the 1980s.
EMPGROW = Total 1980 employment / Total 1970 employment

Data: U.S. Dept. of Commerce, U.S. Census, 1970 and 1980 Selected Tables from CCD files.

URBAN---CLUSTER 1 - Upper Middle
VARIABLE: EMPGROW

CLASS60	N	MEAN	STD DEV	STD ERROR	MINIMUM	MAXIMUM	VARIANCES	T	DF	PROB > |T|
Control 0	9	1.12513604	0.50342147	0.16780716	0.19137725	1.90053763	UNEQUAL	-1.5713	14.5	0.1377
Treated 1	21	1.43558092	0.47790627	0.10428770	0.64504906	2.61630695	EQUAL	-1.6055	28.0	0.1196

FOR HO: VARIANCES ARE EQUAL, F'= 1.11 WITH 8 AND 20 DF PROB > F'= 0.7955

URBAN--CLUSTER 2 - Lower Middle
VARIABLE: EMPGROW

CLASS60	N	MEAN	STD DEV	STD ERROR	MINIMUM	MAXIMUM	VARIANCES	T	DF	PROB > |T|
Control 0	2	1.83897508	0.64626035	0.45697508	1.38200000	2.29595016	UNEQUAL	1.2702	1.7	0.3587
Treated 1	2	1.14808075	0.41719522	0.29500157	0.85307918	1.44308231	EQUAL	1.2702	2.0	0.3318

FOR HO: VARIANCES ARE EQUAL, F'= 2.40 WITH 1 AND 1 DF PROB > F'= 0.7299

URBAN--CLUSTER 3 - High
VARIABLE: EMPGROW

CLASS60	N	MEAN	STD DEV	STD ERROR	MINIMUM	MAXIMUM	VARIANCES	T	DF	PROB > |T|
Control 0	1	0.44244229	.	.	0.44244229	0.44244229	UNEQUAL			
Treated 1	9	1.45893565	0.74355439	0.24785146	0.59107993	2.88217723	EQUAL	-1.2969	8.0	0.2308

NOTE: ALL VALUES ARE THE SAME FOR ONE CLASS LEVEL.

URBAN-- CLUSTER 1 - Upper Middle
VARIABLE: EMPGROW

CLASS70	N	MEAN	STD DEV	STD ERROR	MINIMUM	MAXIMUM	VARIANCES	T	DF	PROB > |T|
Control 0	9	1.12513604	0.50342147	0.16780716	0.19137725	1.90053763	UNEQUAL	0.1242	9.0	0.9039
Treated 1	2	1.10297697	0.08541603	0.06039826	1.04257871	1.16337522	EQUAL	0.0596	9.0	0.9538

FOR HO: VARIANCES ARE EQUAL, F'= 34.74 WITH 8 AND 1 DF PROB > F'= 0.2610

URBAN CLUSTER 2 - Lower Middle
VARIABLE: EMPGROW

CLASS70	N	MEAN	STD DEV	STD ERROR	MINIMUM	MAXIMUM	VARIANCES	T	DF	PROB > |T|
Control 0	2	1.83897508	0.64626035	0.45697508	1.38200000	2.29595016	UNEQUAL	0.3543	1.1	0.7812
Treated 1	2	1.67398168	0.12633002	0.08932881	1.58465286	1.76331049	EQUAL	0.3543	2.0	0.7570

FOR HO: VARIANCES ARE EQUAL, F'= 26.17 WITH 1 AND 1 DF PROB > F'= 0.2458

URBAN CLUSTER 1 - Upper Middle
VARIABLE: EMPGROW

CLASS80	N	MEAN	STD DEV	STD ERROR	MINIMUM	MAXIMUM	VARIANCES	T	DF	PROB > |T|
Control 0	9	1.12513604	0.50342147	0.16780716	0.19137725	1.90053763	UNEQUAL			
Treated 1	1	1.09482759	.	.	1.09482759	1.09482759	EQUAL	0.0571	8.0	0.9559

NOTE: ALL VALUES ARE THE SAME FOR ONE CLASS LEVEL.

FIGURE 2. Z-Regions

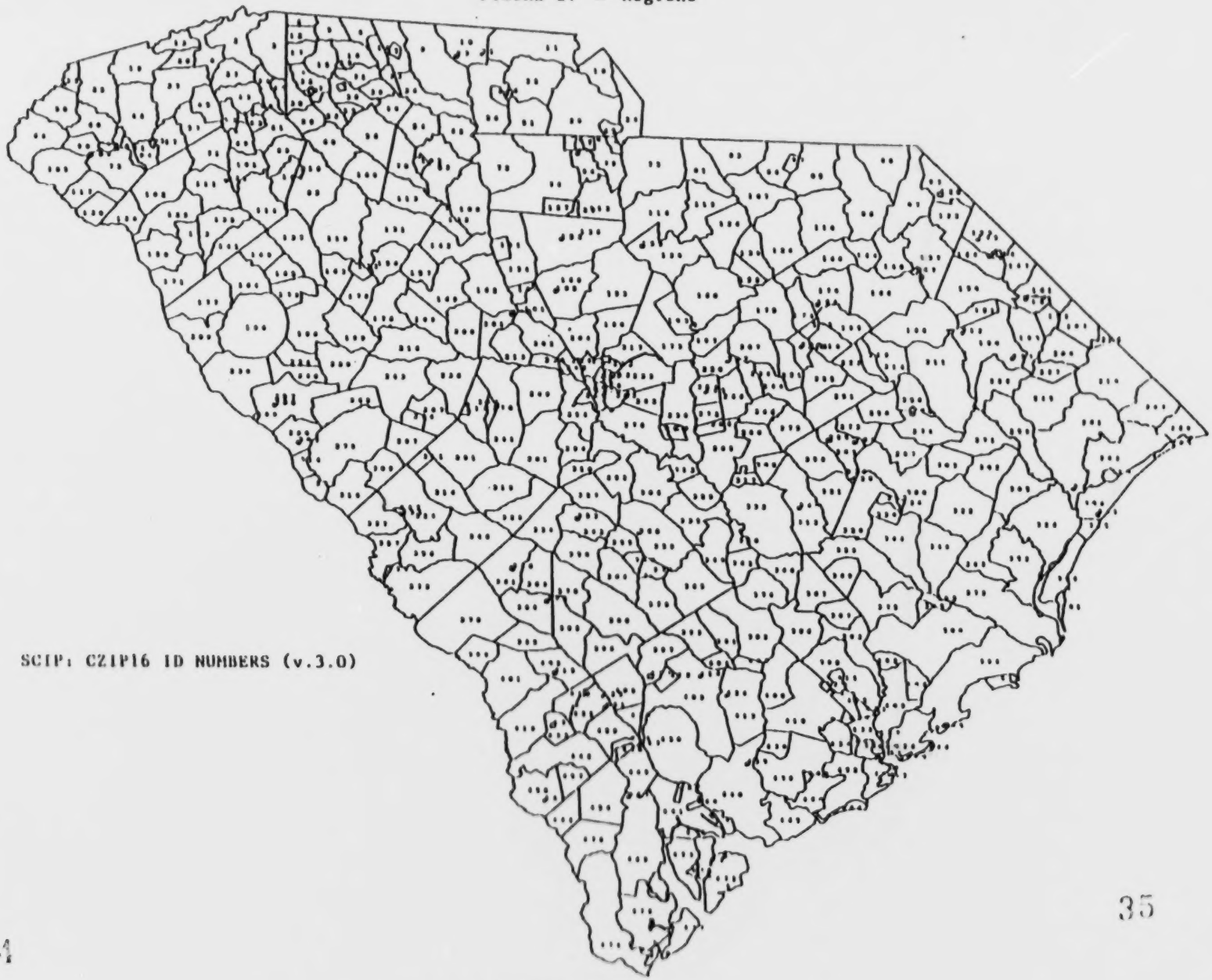

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Table 4A

Dep Var:
Δ Employment in Nonmanufacturing Firms ≥ 25 Employees, 1980-89

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	Parameter=0	Prob > \T\
INTERCEP	1	-2.05	53.96	-0.038	0.9696
ET67	1	0.11	0.006	16.481	0.0001
D60	1	99.74	48.75	2.046	0.0414
D70	1	9.64	53.81	0.179	0.8579
D80	1	351.05	95.76	3.666	0.0003
D67	1	206.13	62.92	3.276	0.0011
D68	1	164.62	98.45	1.672	0.0952
D678	1	309.67	97.98	3.160	0.0017
D78	1	152.35	141.90	1.074	0.2836
HIGH	1	195.68	78.47	2.494	0.0130
MIDHI	1	34.61	56.38	0.614	0.5396
MIDLOW	1	-21.05	56.52	-0.373	0.7096
ZAREA	1	0.02	0.12	0.211	0.8328

ROOT MSE	365.9707	R-SQUARE	0.4719	F VALUE	PROB>F
DEP MEAN	150.7149	ADJ R-SQ	0.4582	34.549	0.0001

Variable Definitions:

ET67: Total Employment in nonmanufacturing firms with 25 or more employees that were established prior to 1980.

D60: Dummy Variable = 1 if 4 lane highway completed in the "Z" region during the 1960s only.
= 0 otherwise

D70: = 1 if 1970s four lane only; else = 0
D80: = 1 if 1980s four lane only; else = 0
D67: = 1 if 1960s + 70s four lane only; else = 0
D68: = 1 if 1960s + 80s four lane only; else = 0
D78: = 1 if 1970s + 80s four lane only; else = 0
D678: = 1 if 1960s, 70s + 80s four lane; else = 0
HIGH = 1 if Z regions in high income class cluster; else = 0
MIDHI = 1 if Z region in mid-high cluster; else = 0
MIDLOW = 1 if Z region in mid-low cluster; else = 0
ZAREA = Area of Z region in square kilometers

Table 4B

Dep Var:
Δ Employment in Manufacturing Firms ≥ 100 Employees, 1980-89

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	T for HO: Parameter=0	Prob > \T\
INTERCEP	1	-26.98	45.60	-0.592	0.5544
ET67	1	0.084	0.014	5.797	0.0001
D60	1	69.22	41.24	1.678	0.0939
D70	1	77.74	45.44	1.711	0.0878
D80	1	293.29	80.91	3.625	0.0003
D67	1	173.51	53.77	3.227	0.0013
D68	1	91.95	83.25	1.105	0.2699
D678	1	306.58	80.56	3.801	0.0002
D78	1	-42.41	119.35	-0.354	0.7236
HIGH	1	304.69	67.97	4.483	0.0001
MIDHI	1	55.81	47.91	1.165	0.2446
MIDLOW	1	10.85	47.72	0.226	0.8210
ZAREA	1	0.057	0.105	0.544	0.5865

ROOT MSE	309.0987	R-SQUARE	0.2622	F VALUE	PROB>F
DEP MEAN	135.6646	ADJ R-SQ	0.2432	13.744	0.0001

Variable Definitions:

ET67: Total Employment in firms - manufacturing with 100 or more employees that were established prior to 1980.

D60: Dummy Variable = 1 if four lane highway completed in the "Z" region during the 1960s only.
= 0 otherwise

D70: = 1 if 1970s four lane only; else = 0
D80: = 1 if 1980s four lane only; else = 0
D67: = 1 if 1960s + 70s four lane only; else = 0
D68: = 1 if 1960s + 80s four lane only; else = 0
D78: = 1 if 1970s + 80s four lane only; else = 0
D678: = 1 if 1960s, 70s + 80s four lane; else = 0
HIGH = 1 if Z regions in high income class cluster; else = 0
MIDHI = 1 if Z region in mid-high cluster; else = 0
MIDLOW = 1 if Z region in mid-low cluster; else = 0
ZAREA = Area of Z region in square kilometers

Table 4C

Dep Var:
Δ Employment in Manufacturing Firms ≤ 100 Employees, 1980-89

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	T for HO: Parameter=0	Prob > \T\
INTERCEP	1	9.79	13.59	0.720	0.4718
ET67	1	0.59	0.04	13.488	0.0001
D60	1	42.99	12.43	3.457	0.0006
D70	1	6.66	13.59	0.490	0.6241
D80	1	34.80	24.16	1.440	0.1504
D67	1	26.33	16.01	1.645	0.1006
D68	1	27.98	24.99	1.120	0.2634
D678	1	64.41	25.19	2.557	0.0109
D78	1	-27.42	35.78	-0.766	0.4438
HIGH	1	-20.37	20.55	-0.991	0.3222
MIDHI	1	-3.22	14.24	-0.227	0.8209
MIDLOW	1	-25.16	14.23	-1.767	0.0778
ZAREA	1	0.05	0.03	1.588	0.1130

ROOT MSE	92.21232	R-SQUARE	0.4314	F VALUE	PROB>F
DEP MEAN	52.02306	ADJ R-SQ	0.4167	29.339	0.0001

Variable Definitions:

ET67: Total Employment in firms - manufacturing with fewer than 100 employees that were established prior to 1980.

D60: Dummy Variable - 1 if 4 lane highway completed in the "Z" region during the 1960s only.
- 0 otherwise

D70: - 1 if 1970s 4 lane only; else - 0
D80: - 1 if 1980s 4 lane only; else - 0
D67: - 1 if 1960s + 70s 4 lane only; else - 0
D68: - 1 if 1960s + 80s 4 lane only; else - 0
D78: - 1 if 1970s + 80s 4 lane only; else - 0
D678: - 1 if 1960s, 70s + 80s 4 lane; else - 0
HIGH - 1 if Z regions in high income class cluster; else - 0
MIDHI - 1 if Z region in mid-high cluster; else - 0
MIDLOW - 1 if Z region in mid-low cluster; else - 0
ZAREA - Area of Z region in square kilometers

The Developmental Impacts of Transportational Investments

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INTRODUCTION

This paper deals with the developmental impacts of infrastructure investments in general and transportation investments in particular. This paper draws heavily on work conducted, and previous papers written, by the author on behalf of the USDA-ERS, Foundations of Rural Development Project, (Johnson, 1990) and the Virginia Department of Transportation, Route US58 Planning Study, both of which are still in progress.

The perspective of the paper is that of an analyst who must predict either (or both) the net economic benefits or the economic impacts of alternative public expenditure programs on transportation infrastructure. The paper necessarily must transcend theoretical and empirical issues in order to determine the most appropriate means of measuring benefits and impacts. The most salient theoretical issues involved in benefit measurement and impact projection will first be raised. Next, issues related to the empirical estimation of economic impacts of infrastructure investments will be reviewed including major strengths and weaknesses of alternative approaches, obstacles to the accurate measurement of economic impacts, data sources and data limitations. Finally, specific methods will be detailed to accomplish these two goals.

For the most part the arguments made here will be appropriate for most types of physical infrastructure (at least as defined below). However, as we will see, there are certain characteristics of transportation, especially its spatial characteristics, which make it somewhat unique. Given the objectives of this paper and of the research to which it is related these unique characteristics will be stressed.

Physical infrastructure is distinguished from other forms of investment, including social infrastructure, on the basis of its locational or spatial fixity. Public investments that lead to effects independent of location (human capital, technology, defense, etc.) are not physical infrastructure.

Physical infrastructure thus includes such things as roads, streets, highways, bridges, airports, recreation facilities, communication facilities, public buildings, industrial sites and water and sewer facilities. Transportation infrastructure is further distinguished from other types of physical infrastructure by its tendency to create corridors and networks in space and its relationship to spatial interindustry trade.

This paper will distinguish between economic impacts and net benefits of physical infrastructure development. Net benefits (the single most relevant measure of economic development) will refer to the difference between costs and benefits to the private sector and to local governments of investments in physical infrastructure. Costs and benefits should not be limited to market determined values but should also include shadow prices and opportunity cost in cases where non-market effects are possible (such as the improved environmental conditions).

Economic impacts, on the other hand, refer to changes in level of economic transactions without concern for whether these are benefits or costs. Impacts and net benefits are, of course, closely related. Impacts include market net benefit effects plus other changes in economic activity. For example, net benefits are changes

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in the total (or some weighted aggregation of) costs and benefits. Economic impacts, on the other hand, are often largely distributional shifts in these benefits and costs among individuals, sectors or locations.

Included in economic impacts are the so-called ripple or multiplier effects of an economic stimulation. They begin immediately and follow almost automatically from the economic change. While these impacts have very important distributional implications at the spatial, sectoral and household levels, the overall net benefits stemming from these ripple effects will be very close to zero when compared to alternative projects.

Net benefits are more fundamental changes in the structure of the economy, in the economic base and in the size and composition of the economic multiplier. A wise investment in infrastructure will increase the productivity of private capital, human capital and other public infrastructure (better roads and bridges will make fire, rescue, police and public education services more efficient, for example). Net benefits stem from the change in efficiency of consumption, as well as production, due to lower unit costs and/or higher valued services. These latter benefits can conceivably have no (or even negative) impacts on economic activity.

Another useful distinction is between short-run and long-run effects. Short-run effects include the distributional economic impacts and the net benefits discussed above that occur as an immediate and direct consequence of the infrastructure investment. Long-run effects occur as the infrastructure stimulates the rate of economic growth and development. This economic growth is in response to the increases in productivity and the improved consumption possibilities discussed above but occurs only when firms and households choose new locations, as employers invest in new plants and equipment and as new markets are developed for the now lower cost products. These long-run effects can also be either distributional or net since new economic growth and development will be stimulated (the net effect) but other growth and development will be attracted from other areas to those areas with new infrastructure.

In practice, net effects, whether short-run or long-run, are much more difficult to measure. As will be seen, far less is known about the process that generates these net effects than about the distributional process. As a result, there are fewer dependable methods developed to predict the net effects, particularly those in the long-run.

The accounting stance influences distributional impacts as well. Many distributional impacts at the state or national level are net benefits or costs from the perspective of a region. If an investment in physical infrastructure leads to the concentration of economic benefits in a particular region (county, city, or town) while costs are borne outside the region, then the project is beneficial from the view of that region. In any event, both the distributional and the net consequences of physical infrastructure investment are of interest to decision makers.

MEASURING THE ROLE OF INFRASTRUCTURE IN ECONOMIC DEVELOPMENT

The objective of this section is to discuss alternative conceptual models of infrastructure's role in economic development. Both the economic impact and the net benefits of infrastructure will be considered. However, since the primary measure of economic development is net benefits, the section will concentrate on this aspect.

Economic Impact

Our interest in the economic impacts of infrastructure investments stems from our desire to know the change in output by sector, the change in government revenues and expenditures and the change in employment, income, prices and sales that will be induced by the new infrastructure.

Johnson (1990) discusses several approaches to measuring the impacts and net benefits of infrastructure development. Several of these are limited in their focus to the impacts only.

These include: 1) input-output analysis and its variants, 2) computable general equilibrium models and 3) spatial equilibrium models.

Input-output analysis needs no description here. Depending on how sophisticated the particular model is (whether interregional, a non-linear variant or a dynamic variant, for example) it may be capable of generating very comprehensive predictions of impacts. Computable general equilibrium models do everything the input-output model can do. In addition, however, it can consider various nonlinear responses and constraints. Spatial equilibrium models (Harris) explicitly consider such spatial characteristics as location rent and land value in estimating sector output levels. Migration may also be estimated in the models. Some spatial equilibrium models interface with an input-output model to predict sector output levels, or with an optimization algorithm to minimize costs of production in sector locations.

Net Benefits

Our interest in the net benefits of infrastructure investments is based on our interest in knowing the increase in value added in new and existing firms, the increase in the utility (quality of life) of new and existing residents and increase in government efficiency.

Johnson (1990) reviews several approaches to the measurement of net benefits from infrastructure investment. These include the following approaches: 1) producer benefits measurement, 2) travel time, 3) willingness to pay, 4) industrial location, 5) residential location and 6) hedonic land valuation.

In the producer benefits approach, the objective is to measure the change in profit among all users of an infrastructure service (Diewert; Gruver; Harris; Kanemoto; Lakshmanan, Mohring and Williamson). Given the general equilibrium nature of economic development, this approach tends to overlook many potential effects of infrastructure, including the change in location of economic activity and the effects on consumers and labor. The travel time approach (Gruver; Mohrin and Williamson) is similar to (and often a part of) the producer benefits measurement approach.

The willingness to pay approach (Diewert) and the producer benefits approach are conceptually equivalent and will generate similar estimates if done accurately. As in all willingness to pay studies, it is difficult to get respondents to give their evaluations accurately and honestly. This measure also ignores the new location of industries and residents because of the investment.

Industry and residential location approaches are a common, indirect way to estimate the benefits of infrastructure investments (Kuehn, Brashler, and Shonkwiler; Carlino and Mills; Dorf and Emerson; Kriesel; Hastings and Goode. This approach explicitly considers the longer-term issue of development effects but does not provide, in itself, measure of benefits. In concert, location measures, plus willingness to pay, and producer benefit measures could provide a more reasonable estimate of net benefits, but the method tends to become very ad hoc and susceptible to error.

It is the author's conclusion that the hedonic land value method is the only method reviewed that is conceptually capable of comprehensively measuring the net benefits of infrastructure investment. This approach is discussed in detail below. Since infrastructure investments are defined as locationally specific, it follows from economic theory that their benefits and costs (along with the benefits and costs of other spatial attributes including local services and amenities) will be capitalized into the value of real property as spatial equilibrium is established. This capitalized value is known as Ricardian Rent. Prior to the establishment of this equilibrium, quasi-rent or short-run profits will be earned by someone. Some Richardian Rent values will be highly location specific (for example, within a mile of an interstate ramp, or within the service area of a water system), while others will be much more widespread (within a county that provides solid and hazardous waste services, for example).

When economic disequilibrium is introduced through some change other than an investment in infrastructure, the impacts will first be reflected in changes in the price of outputs and/or inputs. However, these price changes will lead to changes in quasi-rent, in

the short-run, and to changes in the level and/or location of production in the longer-run. Through this industrial and business location process spatial equilibrium is reestablished with new levels at Ricardian Rent. Note that since land is used to some extent by many sectors, including residential housing, this spatial equilibrium will involve the relocation of other types of production and households. Furthermore, since local governments provide local public services based on their revenues and the demand for the services, some further changes will occur in response to changes.

These arguments would suggest, then, that changes in land value should indicate the change in net benefits (economic development) generated by the infrastructure investment. It follows that analysis of land values and their relationship to infrastructure investments will allow a measurement of the developmental effects of infrastructure. The validity of this argument rests on a number of critical assumptions.

These include:

1. The land market is perfect.
   A perfect land market will assure that values reflect the maximum Ricardian Rent possible from the land.

2. Perfect information.
   If current land values are to reflect discounted future land uses, perfect information about future uses and returns is required. On the other hand, if there are real risks in the future, (with objective probabilities), then land values should reflect these imperfections in information.

3. No transactions costs.
   One view is that high transactions costs prevent land from gravitating to its highest and best use. Land values then reflect lower than ideal levels. On the other hand, one can argue that transactions costs are a cost of transion and thus correctly reduce land values.

4. The land market is in equilibrium.
   Equilibrium, of course, is never achieved in the real world. Some quasi-rent (positive or negative) is always being earned. On the other hand, land speculators tend to adjust marginal land values quite rapidly--much more rapidly than land uses adjust. Thus, land prices established by recent sales should reflect, reasonably well, the future (equilibrium) land uses and value.

5. A marginal change in infrastructure.
   A large investment may lead to a violation of the perfect market assumption since it may require too many customers and producers to move in order to capitalize benefits.

This conceptual model requires a highly sophisticated temporal structure to capture the causality in the economic development process. This structure has the following characteristics:

1. The response of property values to economic stimuli will begin when investors anticipate the change rather than when it occurs. As investors become more certain that the change will occur, the response of property values will strengthen. Thus, some of the change in value, particularly that in unimproved land, will occur before the investment begins. Other increases in value will occur after the investment as investments in improvements occur and as the rate of development accelerates.

2. If infrastructure is a necessary and sufficient condition for economic development, then land values will always rise in response to (see 1 above) investments in infrastructure.

3. If infrastructure is a sufficient but not necessary condition for development, then the level of infrastructure will be

related to at least some minimum level of economic development.

4. If infrastructure is a necessary but not sufficient condition for development, then the level of economic development will be related to at least some minimum level of infrastructure.

5. If economic development proceeds, or enables the development of infrastructure (i.e. economic development is a necessary condition for infrastructure), then a situation similar to 3 above will be expected. The literature on the use of hedonic land valuation is very mixed. Arnott concludes, on the basis of conceptual arguments, that only part of benefits of such spatial investments as transportation will be capitalized into land values and that this approach will underestimate the benefits. Arnott argues that if the economy is not sufficiently open, new residents and firms will not bid up the land prices sufficiently to capitalize all benefits. Secondly, if similar improvements occur widely, then the demand will again be insufficient to fully capitalize benefits. Finally, Arnott argues that if the land buyers are not identical, then some changes in consumer (and presumably producer) surplus will occur which are not reflected in the marginal valuation of land. This latter point is a rather inconsequential point when reasonably small changes take place. The first two conditions essentially require that the market operate reasonably well.

Kanemoto (1988) develops a rigorous general equilibrium treatment of the issues. He assumes a competitive market and considers the ex ante measurement of benefits and costs using hedonic landprices. In stark contrast to Arnott, Kanemoto concludes that:

1. hedonic places will in general overestimate benefits;

2. hedonic price estimates of benefits will be accurate if prices and wages do not change because of the investment or if production and utility functions do not permit substitutability among commodities;

3. the hedonic price approach does include the consumer's surplus;

4. heterogeneity in consumers tends to reinforce the paper's conclusions;

5. hedonic pricing is preferable to direct measures of infrastructure price because the latter ignores consumer's surplus;

6. benefits received by producers are measured equally well by hedonic prices if long-run, free entry competition is assumed;

7. the results are unchanged if we assume that labor supply is endogenous, that is, if workers determine the number of hours they work based on wages and prices; and

8. the results are unchanged if wage rates are dependent on infrastructure, if land is demanded by both consumers and producers, since any wage rate differences due to infrastructure and amenities will be reflected in the bid price for commercial and industrial land;

9. "the hedonic measure can be used as an upper bound estimate...If mobility is imperfect, capitalization tends to be less than perfect, which creates a counteracting tendency for underestimation and the net result is uncertain (p.989)."

McHone reports on an empirical test of a theory developed by Fishel and later by Fox (1978). This theory relates location rent, local tax rates, and industrial development. McHone empirically estimates a simultaneous model in which tax payments per employee and manufacturing employees per capita are price and quantity variables respectively in supply and demand functions for industrial locations. The price of land is a significant variable in the demand function. The study indicates that manufacturing firms pay for some locational value through taxes and capitalize the rest into land values. This is consistent with the conceptual predictions of Kanemoto and suggests that total benefits should be increased by the change in tax revenues collected due to the infrastructure investment.

Summarizing this section, then, it seems reasonable that neither imperfect markets, imperfect information, transactions costs or disequilibrium will reduce the ability of land values to indicate future economic development levels and the net benefits thereof. Instead, each of these imperfections, if they exist, will tend to limit the rate of economic development--a matter that concerns us but not in terms of our ability to measure it.

A PROPOSED HEDONIC LAND PRICES MODEL

We hypothesize the following hedonic land price equation,

LAND VALUES = f (TRANSPi, INFRASi, PUBLICSERVEi, MARKETSi, INPUTSi, COSTSi, PLACEi)

where the variables are defined as follows:

TRANSP

This group of variables includes indices of access to various modes of transportation, including interstate, primary road, air service and shipping.

INFRAS

This will include measures of other important infrastructure service including water, sewer, industrial sites, communications and colleges.

PUBLICSERVE

This group will include measures of the important noninfrastructural public services such as police, education, fire protection, jails, etc.

MARKETS

These variables will measure the size and purchasing power of each area's markets. This will include population, income, and demographics weighted by effective distance.

INPUTS

These variables will include the costs and availability of inputs to the area's producers and the cost and availability of consumer goods and services.

PLACE

This group includes place-specific amenities and variations in productivity.

EMPIRICAL ANALYSIS USING A GIS

A geographic information system (GIS) will serve as the basis for generation and storage of the data needed for the model above. A GIS organizes, stores and facilitates the analysis of data and allows the generation of compound or derivative data.

The new Census Bureau TIGER file for the state of Virginia and bordering counties will be used as the base map for the study. The TIGER files include all county and municipal boundaries, minor civil division, census tracts, census blocks, rivers, streams, roads, highways, streets, bridges, major institutions, airports and much more. In addition, we will superimpose the zip code boundaries and the USGS land use maps over the TIGER files. Large numbers of

data have been collected to apply to these base maps. Time series of such data as employment by sector, population, income, socioeconomic characteristics, and sales have been acquired at the census tract level. A sample of several thousand land sales is being collected and entered by location of property. The size of the property, the land use class, the value of unimproved land, and the value of improvements are being entered. The capacity and service areas of water and sewer service will be digitized in the data base as well. The states expenditures on road construction and improvement will be entered by road segment with the year that it was planned and the year that it was completed. County and town data on expenditures for key public services, tax rates, amenity levels will be included.

The GIS will be used to generate certain spatial and compound variables. Some examples of compound data needed in this study include:

- Air service indices: distance to airport, speed limits, traffic congestion, flight frequency and layover time.

- Interstate access indices: travel time to interstate including bridge limits, speed limits and number of lanes.

- Industrial site indices: size of site topography, access to water, sewer, road, railroad, air service, and interstate highway.

- Distance to metropolitan area

- Distance to colleges, schools, markets, etc.

The data generated by the GIS will be arranged into time-series/cross-sectional observations on land values and exported to a statistical analysis program. The relationship generated in the earlier section of the paper will be estimated to generate parameters.

When the analysis is complete the estimated parameters will be imported into the GIS and used for development of graphics, further analysis, validation, etc. Most importantly, the GIS will be used for simulations to predict the impact of changes in physical infrastructure. The geographic simulator will estimate the total benefits of various alternative routes for the highway, two lane versus four lane construction, full access versus limited access, and location of access ramps. Because of the spatial interactions involved, many of these alternatives must be compared in combination.

CONCLUSION

The analysis of the developmental effects of transportation investments described here is very time consuming and expensive. On the other hand, the magnitude of the investments and their consequences and the importance to the economic vitality of states are so large that such extreme measures are easily justified. The GIS based hedonic approach outlined here will provide detailed projections of the location, timing and magnitude of benefits from an almost infinite number of highway development alternatives.

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GIS: A New Tool for Local Economic Development

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INTRODUCTION

A geographic information system (GIS) combines hardware and software tools to maintain, retrieve, and manipulate both spatial and nonspatial data about places. The development of computer graphics for spatial analysis has benefitted from parallel research in data automation in the fields of cadastral and topographical mapping, geography, thematic cartography, civil engineering, utility networks, soil science, land use planning, surveying and photogrammetry, remote sensing technology and mathematical spatial analysis. The chief advantage of a GIS is that it allows interactive access, manipulation or transformation of data for the purpose of replicating a real world model. It is possible to use the system for the construction of hypothetical scenarios that might result from planning decisions, for instance. In this context then, a GIS serves as an experimental laboratory for analyzing the results of planning policies (Burroughs, 1987).

The Orpheus Project, as an example, illustrates a recent attempt to combine a GIS with a regional macroeconomic model customized for the state of Illinois. Project goals are to model locational-specific impacts of a hypothetical computer equipment manufacturing plant in a Chicago suburban community that would employ 1500 people (Johnson, et al., 1988). Although the regional forecasting model is successful in forecasting primary and secondary impacts on employment, income, consumption, investment and population at a ten-county regional level, lack of data limits disaggregation to a sub-regional area. Thus, to identify these forecasted changes at the disaggregated level, 1980 Census travel time-to-work data for the nine township area around the community are utilized to approximate a reasonable driving distance from the plant to residences. GIS (ARC-INFO) is incorporated in the analysis at this point to "clip out" areas and create a "buffer" surrounding the sub-region likely to witness residential and commercial development in proximity to the proposed plant. Similarity between the identified sub-region and nine township area allows acceptance of the buffer zone as the representative sub-region.

Tomlin and Johnston (1988) apply the results from the Orpheus Project to analyze specific new land uses for the area identified previously. They devise 16 new land uses, the most important of which is a research and development facility (that would itself employ 1500 people) for a hypothetical high-tech manufacturing plant. The procedure involves development of a descriptive model to characterize different sites for new land use based on relative suitability (derived from study team suitability ratings from 0 to 100) given site and situation criteria. Site criteria require organization of data related to physiographic, political or perhaps socioeconomic variables as well as proximity to existing land uses. Situation criteria include

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those involving relationships between the proposed use of land and any other proposal for land usage. Secondly, a prescriptive model is constructed to develop options as to how to best achieve the described suitability of location. Using the GIS, land use suitability maps are generated by isolating relevant characteristics and transforming this ranked data into "coverages" or intermediate map "layers" illustrating different factors that affect site suitability. To treat the situation criteria, distance zones are created in coverages and ranked in terms of desirable proximity to neighboring land uses. Reiteration of this entire process improves the accuracy of the prescriptive component while criteria could be adjusted based on site-specific conflicts.

In contrast, Pickett, et al., (1988) incorporate GIS technology to model impacts of non-point source pollution of urban fringe land development in Dane County, Wisconsin. They emphasize the value of GIS in evaluating land use policy goals rather than the implementation of land use plans.

Meanwhile, the state of Vermont, as part of its recent (1988) Growth Management Act, proposes to fund the development of a statewide GIS. The purpose for the GIS will be to maintain accurate information for planning at state, regional, and town agency levels of government. This GIS will increase, presumably, efficiency among planning agencies and eliminate planning oversights through increased communication and data sharing.

Similar research efforts are underway in South Carolina to create a statewide GIS. This project involves the study and modeling of economic development activities with the initial goal being to provide input for decisions regarding physical infrastructure improvement and industrial site selection decisions. Ultimately, it is intended to provide information and analytical tools for development of a statewide strategic plan for infrastructure improvement and economic development.

In light of these statewide and area specific applications of GIS, economists have become increasingly aware of the timeliness of GIS in analyzing economic problems. This is true particularly with regards to the needs of the rural economy as many rural development activities are resource based and require location specific data (Wunderlich, 1988). In fact a growing interest has evolved regarding the economics of such modern land information technology. Luzar (1988), in examining economic perspectives on precision in modern land information assembly, asserts that existing limitations are as of yet due to developing stages of such technology.

Additionally, Niemann and Moyer (1988) suggest questions for future research concerning, within the context of economic theory, the impact of information technology. They ask, for example, how can the demand for land information be incorporated into optimal market and behavioral models. That is, how does the creation of such elaborate land use systems producing descriptive and prescriptive models affect economic behavior? And, what are the specific uses and limitations that might exist regarding conventional benefit/cost studies in relation to information systems?

Johnson (1990) is using GIS to create the spatial variables needed in the estimation of a statewide hedonic model of land values in Virginia. He argues that infrastructure investments like new highways can be evaluated in terms of the net benefits that they generate and that these benefits are captured in pre and post project changes in land values.

Extension specialists have several projects underway in Mississippi to train local officials in the use of GIS to manage data in ways that will improve local decisions (Schmidt, 1990). Issues of concern range from zoning, tax map updates and data processing to sighting of solid waste sites that meet selected physical and socio- economic criteria.

USE OF GIS TO EVALUATE INFRASTRUCTURE INVESTMENTS IN S.C.

Public investment in highways is often viewed by policymakers as an effective tool

for stimulating regional economic development. Economists (Eberts, 1990) give mixed reviews to the role that highways play in economic development. Still, many policymakers are enthusiastic supporters of these concrete efforts to develop lagging areas. And, the politics of which areas receive this public bounty are often more interesting and important to actual investment decisions than the engineering and economic analyses that suggest optimal routes for the selection of new highway investments.

However, politics can also push decision makers toward engineering and economic analyses as a way to relieve the pressures they feel from local groups that claim to be in the area of greatest need. The project we discuss in this paper is rooted in this process for the state of South Carolina. And, it embraces a GIS as part of the technocratic solution to the politics of public investment decisions. But GIS alone cannot isolate the effect of highway investment on economic development of a region. From the perspective of regional economies, the way in which new highways affect economic development must be considered within a conceptual framework of regional economic change. Without the conceptual framework, there is no way to account for the other influences on economic change and thus no way to isolate the effects that added highway investment may have on regional economies.

From the perspective of the individual firm seeking to locate or expand a plant, the effect of improved highway access can not be measured with GIS alone. Again, a conceptual framework is required that will isolate the influence of improved highways on business location decisions while holding other influences constant. However, in both the aggregate region and individual plant cases, GIS provides spatial observations and methods for capturing the influence of space on regional economic development that are new and valuable additions to the regional analyst. For this paper, we focus on these GIS contributions to the analysis of the effects of highway investment on economic development in regions of South Carolina. Accordingly, the economic modelling and econometric issues are mentioned only briefly.

The GIS (ARCINFO) currently being tested as one tool for evaluating economic impacts of investment in S.C. four lane highways and water/sewer services has been used in three areas: data development, regional delineation, and network and policy analysis. We discuss each of these areas next.

Data Development

The University of South Carolina(USC) has had primary responsibility for geocoding water and sewer lines in the state and assembling all the data files available from government sources. At Clemson we have all the GIS files from USC--TIGER, DIME, DLGs, Municipal, Counties, CCDs, Water and Sewer, etc.-- and we have developed GIS files from three sources: Census(1970 and 1980) at the CCD level, S.C. Industrial Directory (SCID) at the site and highway corridor levels, and the Dun and Bradstreet (DB) at the site level for firms with more than 25 employees and at the CCD and ZIP level for all DB firms. Data geocoded include the SCID files, and, with a few exceptions, the Dun and Bradstreet files for manufacturing firms not in the SCID files that have more than 25 employees, and the DB files for non-manufacturing firms (excluding local government agencies) that have more than 25 employees.

Equally important are the set of ARCINFO procedures that create spatial data that are linked to plant level observations. Here, the use of the "Near" procedures enable us to begin with point observations on plants and compute the distances to various infrastructure attributes in place or to new infrastructure investments. We refer to these data as spatial point data. Since we have data on year the plant was established (Dun and Bradstreet, S.C. Industrial Directory) and years that infrastructure projects were completed (South Carolina Dept. of Highways), the temporal association between

infrastructure investment and plant operation may be estimated for different industry groups. We can estimate the effect on this association that initial socioeconomic conditions in a region may have.

Distances of each of the SCID firms to four lane interstate, U.S. and S.C. highways have been computed within a 5 KM buffer. Density/distance relationships have been estimated and plotted (Figures 1A-1D). For historical highway files, we have plotted and estimated distance decay functions for the SCID firms. We have repeated this process for firm distances to water and sewer lines--systems Figure 1A for which we have historical data and treatment capacity (Figures 2A, 2B).

Regional Delineation

ARCINFO plays a critical role in defining the spatial units of observation. Spatial observations have traditionally been limited to political subdivisions--such as counties or to Census regions such as County Census Divisions (CCDs) or census tracts in metropolitan areas. However, using GIS, we are overlaying the CCD boundaries with the Zip code boundaries so that we can allocate Dun and Bradstreet firm level data to "CCDZIP" regions.

Within each of these CCDZIP regions we can aggregate the firm level data to a wide range of industrial aggregates. We start with fourteen division level industry groups and compute the number of firms by group, by year started for each region. We find the current employment levels in each of those groups.

Estimates are made from 1970 and 1980 Census data of the initial conditions in 1970 of household income and employment rates of the civilian labor force by CCD. Here we have found four clusters of CCDs that are similar in terms of employment status and household incomes in 1970. At this juncture, by using initial conditions in 1970 to cluster CCDs, we establish four CCD groups that have grown--or stagnated-- in a similar fashion over some prior time period. Then, the question becomes how have each of the CCDs within a cluster responded to the highway treatment prior to and during the 1970s relative to their "peer" CCDs that were not aided by a four-lane highway investment prior to or during the 1970s. Figure 2A.

Beyond 1980 the data we work with at the sub-county level are the employment data from the S.C. Industrial Directory (SCID) and Dun and Bradstreet (DB). As mentioned in the data devel- opment section, we have the SCID data point located in the state and the DB firms with more than 25 employees are point located. We allocate all of these firms--about 3000 SCID manufacturing firms and about 50,000 other DB firms-- to one of our 477 Z regions based on zip and county/ccd codes assigned to each observation. In total, about 1.3 million employees are geolocated in this fashion. The areal density (per square kilometer) of these employees in the Z regions, and the current four-lane highway system are shown in Fig. 3.

At this juncture we assign each of the Z regions to a CCD cluster based on 1970 economic conditions. The Z regions that were treated with four lane highways are then identified and the employment generated in firms established during the 1980s is estimated for the treated and control Z regions (Figures 4A-4D for regions by cluster that form the treatment and control groups). Results suggest that prior four lane highway treatment matters in employment change (see Henry, et al., 1990).

Network and Policy Analysis

One of the most useful aspects of GIS for local economic development practitioners is the capability of GIS to simulate times and distances over space under alternative networks of roads, traffic conditions, and an array of potential impediments-- speed limits, intersection control, bridge crossings, etc.

Obvious applications of these procedures exist in the areas of routing for school busses, EMS and solid waste disposal and sighting.

One case study in South Carolina is under development to use these techniques in the development of a public/private enterprise to run a transportation service between persistent poverty areas and the booming (and labor short) island of Hilton Head (Figure 5). In this case routing, timing and pricing policies will be simulated with respect to their impact on ridership patterns to and from the island.

A second case study in S.C. is under development that would simulate the likely developmental impacts on Greenville County of adding a new four lane highway connector to existing interstates in the southern part of the county. The SCIP project underway is designed to evaluate the impacts of putting new four lane highways into the rural parts of the state.

CONCLUSIONS

To date, we have found GIS to be very helpful in the creation of spatial variables that are in turn used to test developmental policy hypotheses and to estimate parameters for more formal econometric models. The ability to simulate time and distance responses to changes in transportation networks is adding a degree of data reality that should improve our understanding of the importance of the friction of distance to businesses, households and governmental units. In addition to improvements in data quality and thus parameter estimates, the ability to visualize large batches of spatial and temporal data using GIS helps to convey the results of research to policymakers. If GIS can help to bridge the gap between research results that show up in scientific journals and the willingness of policy makers to make decisions based on the best evidence available, the cost of buying into GIS may be small relative to the benefits of more effective public infrastructure investment policy.

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FIGURE 1A

COUNT OF MANUFACTURING FIRMS LOCATED NEAR
FOUR-LANE HIGHWAYS COMPLETED BY 1970

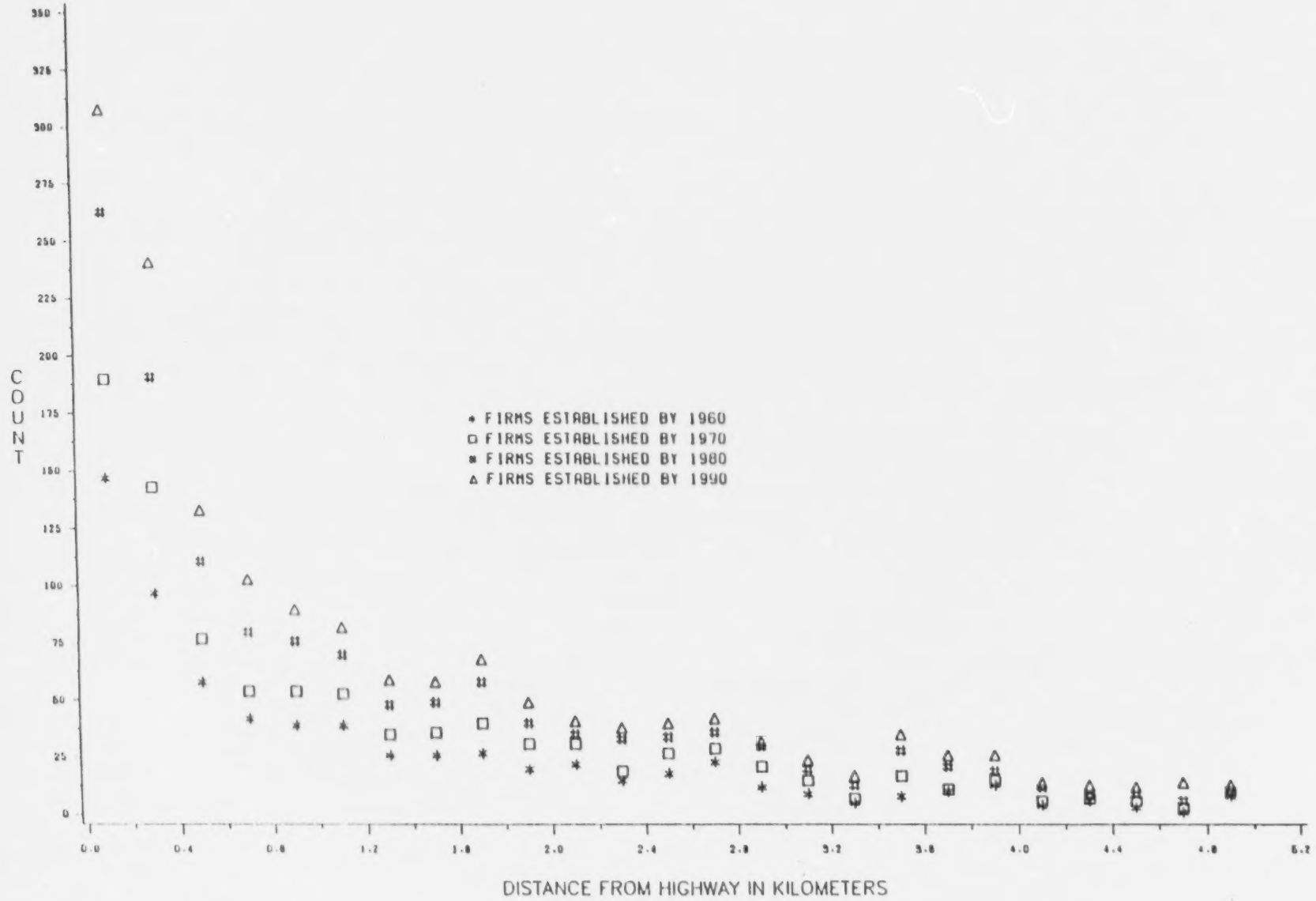
COUNT
* FIRMS ESTABLISHED BY 1960
□ FIRMS ESTABLISHED BY 1970
FIRMS ESTABLISHED BY 1980
△ FIRMS ESTABLISHED BY 1990
DISTANCE FROM HIGHWAY IN KILOMETERS

FIGURE 1B

COUNT OF MANUFACTURING FIRMS LOCATED NEAR
FOUR-LANE HIGHWAYS COMPLETED BETWEEN 1971-1980

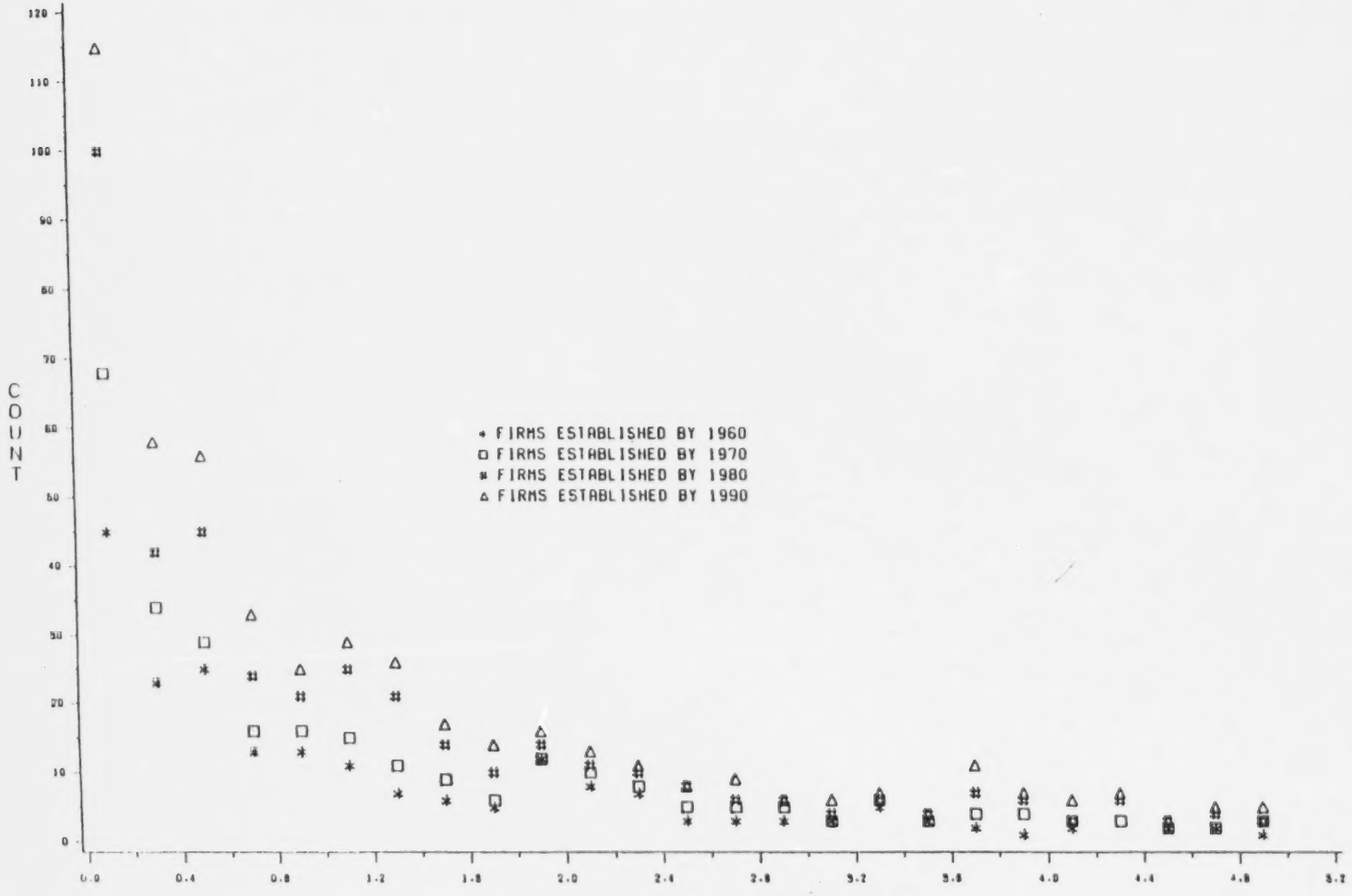
COUNT
* FIRMS ESTABLISHED BY 1960
□ FIRMS ESTABLISHED BY 1970
FIRMS ESTABLISHED BY 1980
△ FIRMS ESTABLISHED BY 1990
DISTANCE FROM HIGHWAY IN KILOMETERS

FIGURE 1C

COUNT OF MANUFACTURING FIRMS LOCATED NEAR
FOUR-LANE HIGHWAYS COMPLETED BETWEEN 1981-1990

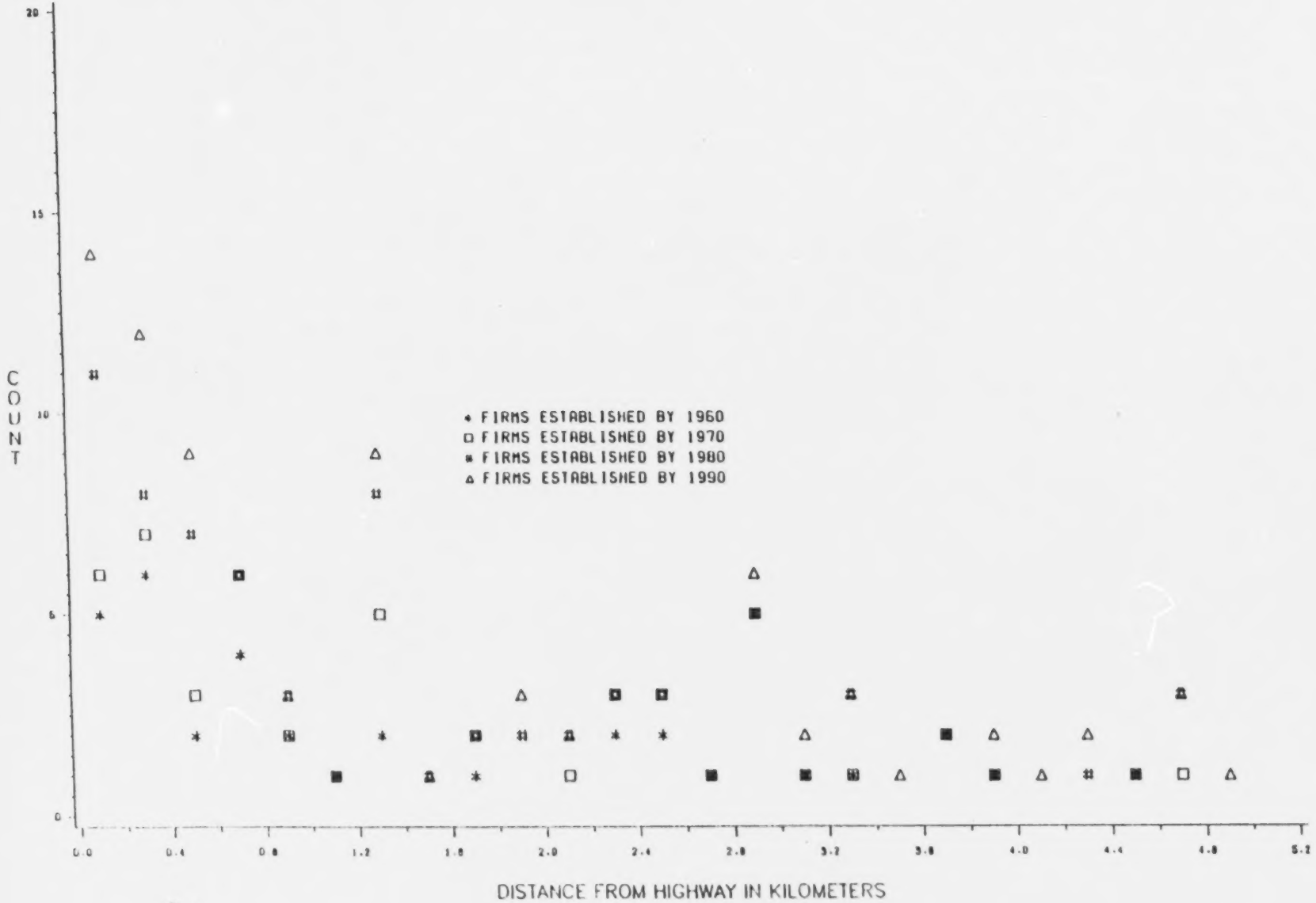

FIGURE 1D

HIGHWAYS COMPLETED BY 1970	DEPENDENT VARIABLE: NUMBER OF FIRMS	LINEAR DISTANCE CONSTANT	LINEAR DISTANCE SLOPE	LINEAR ADJ R2	QUADRATIC CONSTANT	QUADRATIC DISTANCE B1	QUADRATIC DISTANCE SQUARED B2	QUADRATIC ADJ R2
	BY 1960	69.22	-16.84	0.56	102.74	-57.03	8.04	0.78
	BY 1970	94.33	-22.74	0.57	138.02	-75.13	10.48	0.78
	BY 1980	130.05	-31.21	0.58	190.32	-103.47	14.45	0.79
	BY 1989	156.03	-37.17	0.57	230.88	-126.91	17.95	0.8
FROM 1971 TO 1980								
	BY 1960	21.24	-5.24	0.55	31.25	-17.3	2.43	0.76
	BY 1970	28.7	-6.97	0.49	44.09	-25.41	3.39	0.73
	BY 1980	41.46	-10.13	0.49	64.09	-37.28	5.43	0.73
	BY 1989	50.67	-12.31	0.52	78.63	-45.84	6.7	0.78
FROM 1981 TO 1989								
	BY 1960	3.62	-0.63	0.23	4.4	-1.85	0.28	0.26
	BY 1970	4.8	-0.93	0.38	5.64	-2.06	0.24	0.39
	BY 1980	6.33	-1.28	0.37	8.9	-4.52	0.68	0.54
	BY 1989	7.71	-1.6	0.4	11.19	-5.77	0.83	0.58

FIGURE 2A

COUNT OF MANUFACTURING FIRMS LOCATED NEAR WATER LINES

FIGURE 2B

COUNT OF MANUFACTURING FIRMS LOCATED NEAR SEWER LINES

FIGURE 3A

< 0.0010
0.0010 - 0.5099
0.5100 - 3.3999
3.4000 - 16.7999
> 16.8000
EMP DENSITY: TOT EMP DENSITY

FIGURE 3B

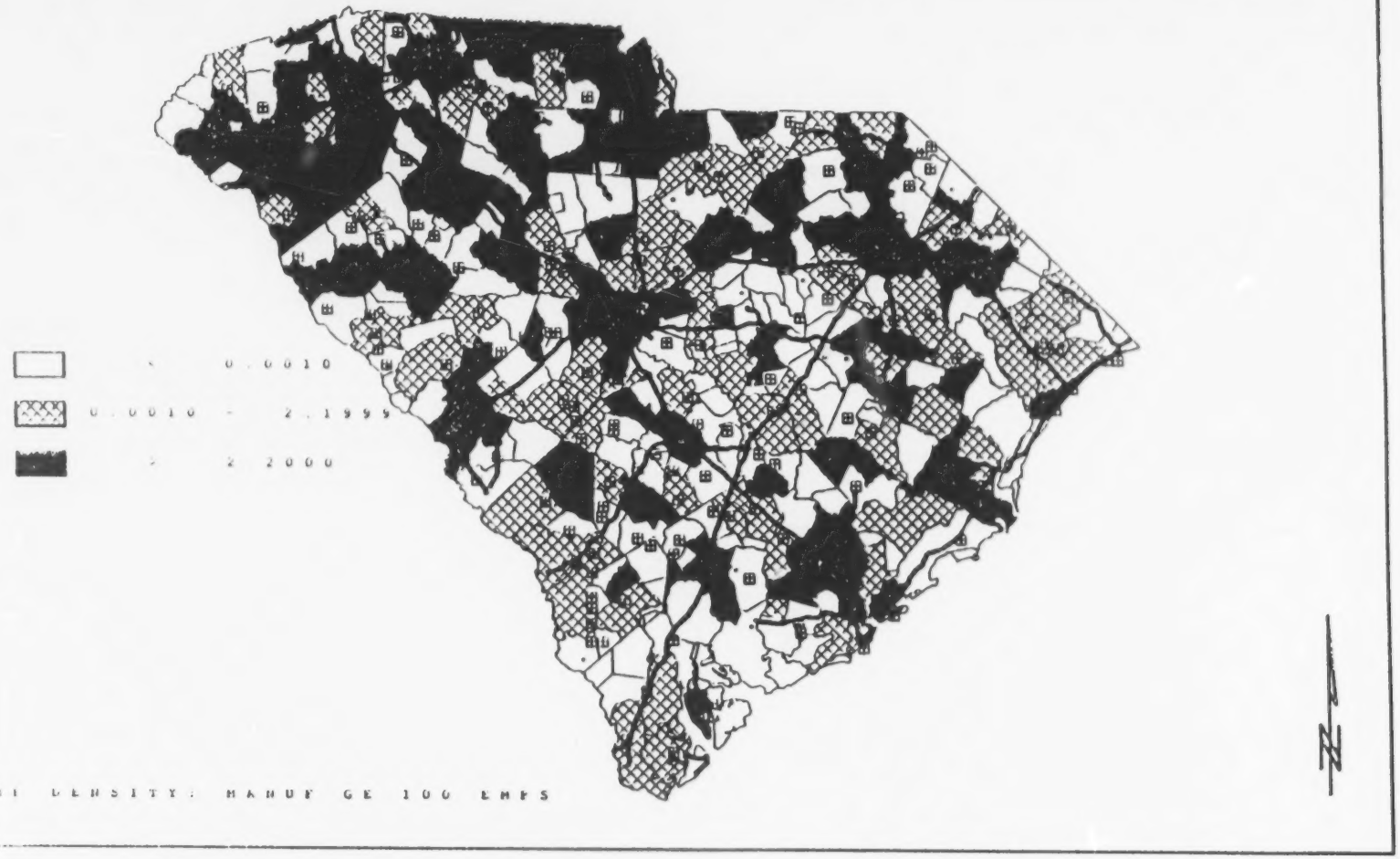

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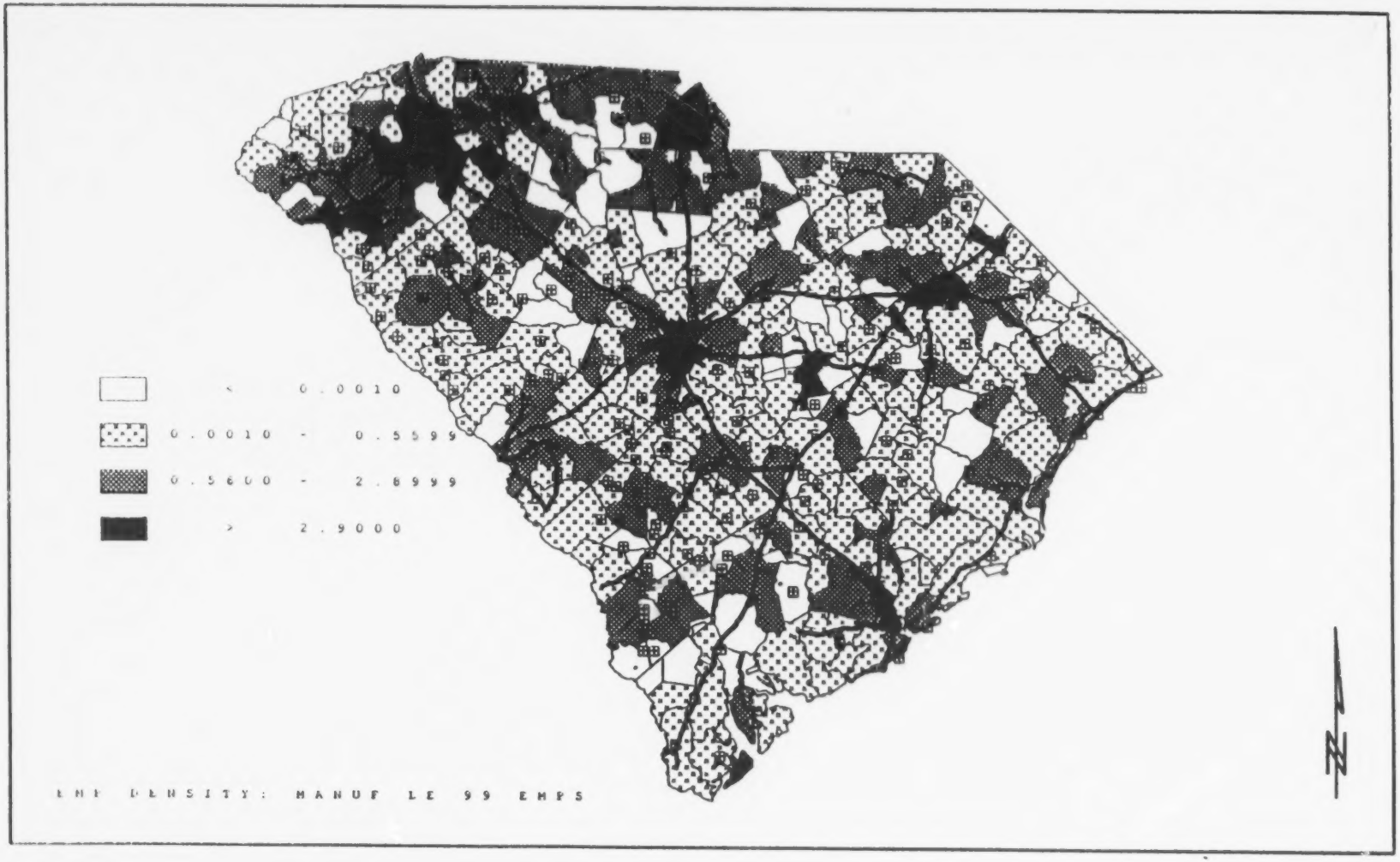
FIGURE 3C


< 0.0010
0.0010 - 0.5599
0.5600 - 2.8999
> 2.9000
ENT DENSITY: MANUF LE 99 EMPS

50

FIGURE 3D

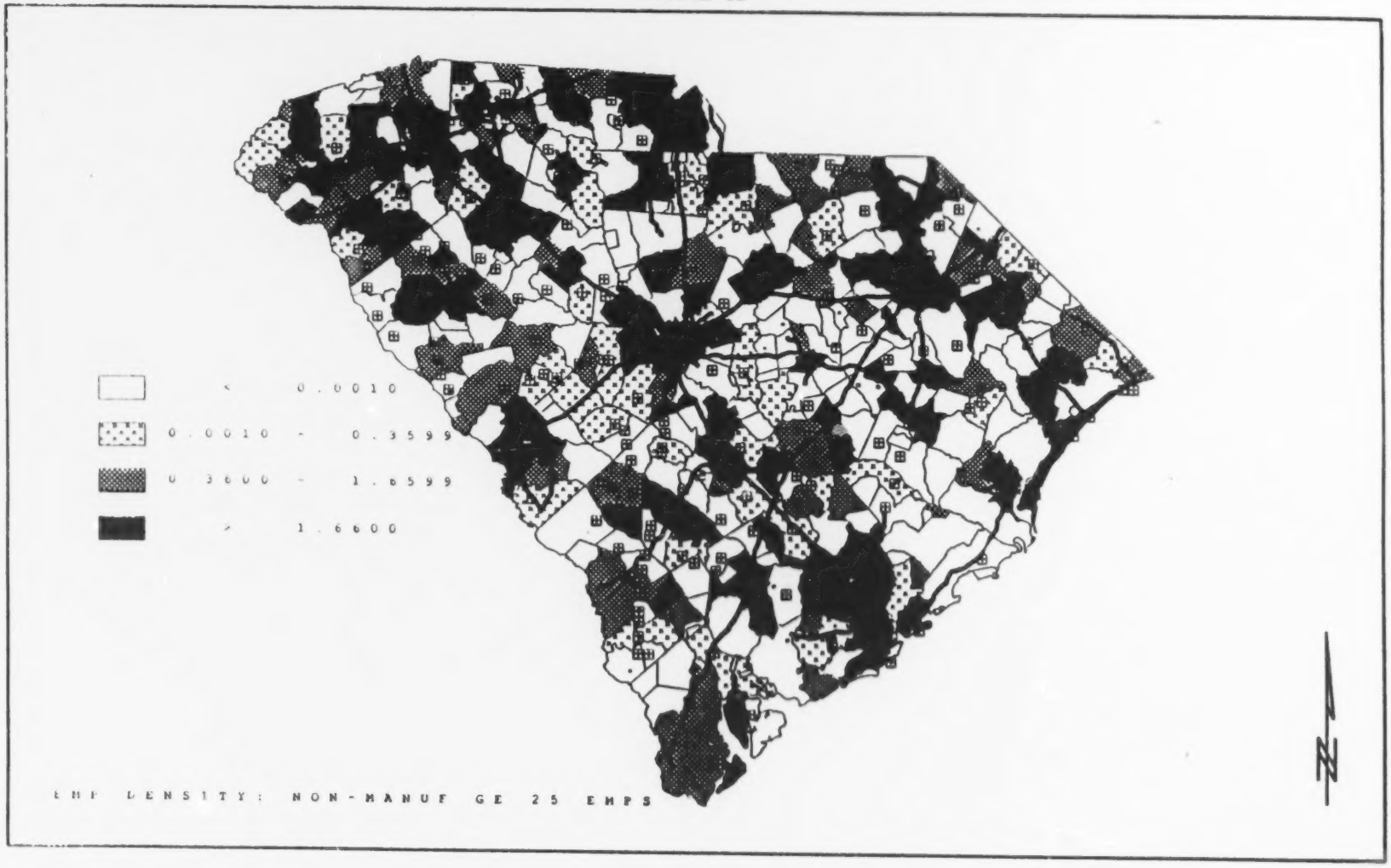
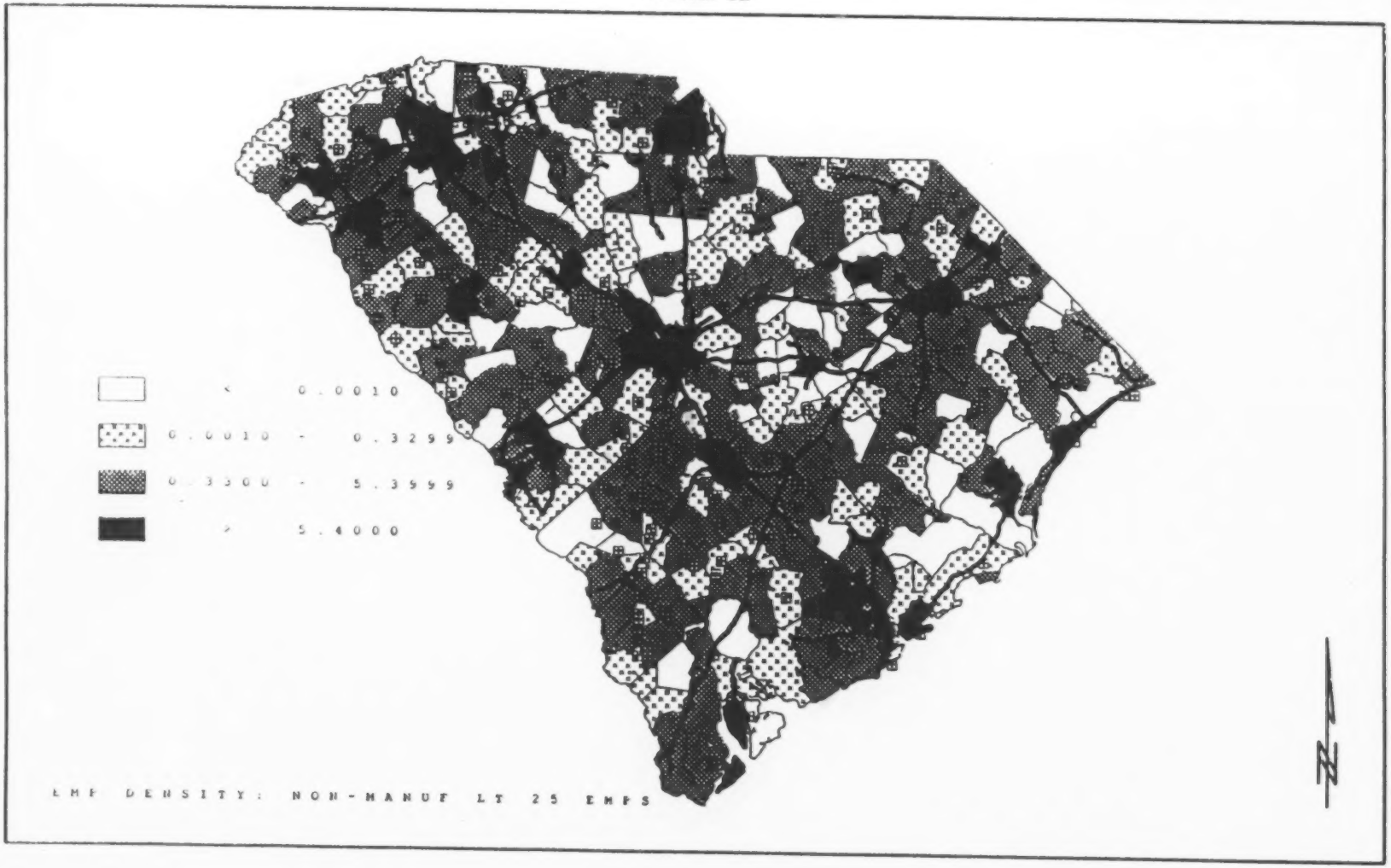

< 0.0010
0.0010 - 0.3599
0.3600 - 1.6599
> 1.6600
EMP DENSITY: NON-MANUF GE 25 EMPS

FIGURE 3E


< 0.0010
0.0010 - 0.3299
0.3300 - 5.3999
> 5.4000
EMF DENSITY: NON-MANUF LT 25 EMFS

52

FIGURE 4A

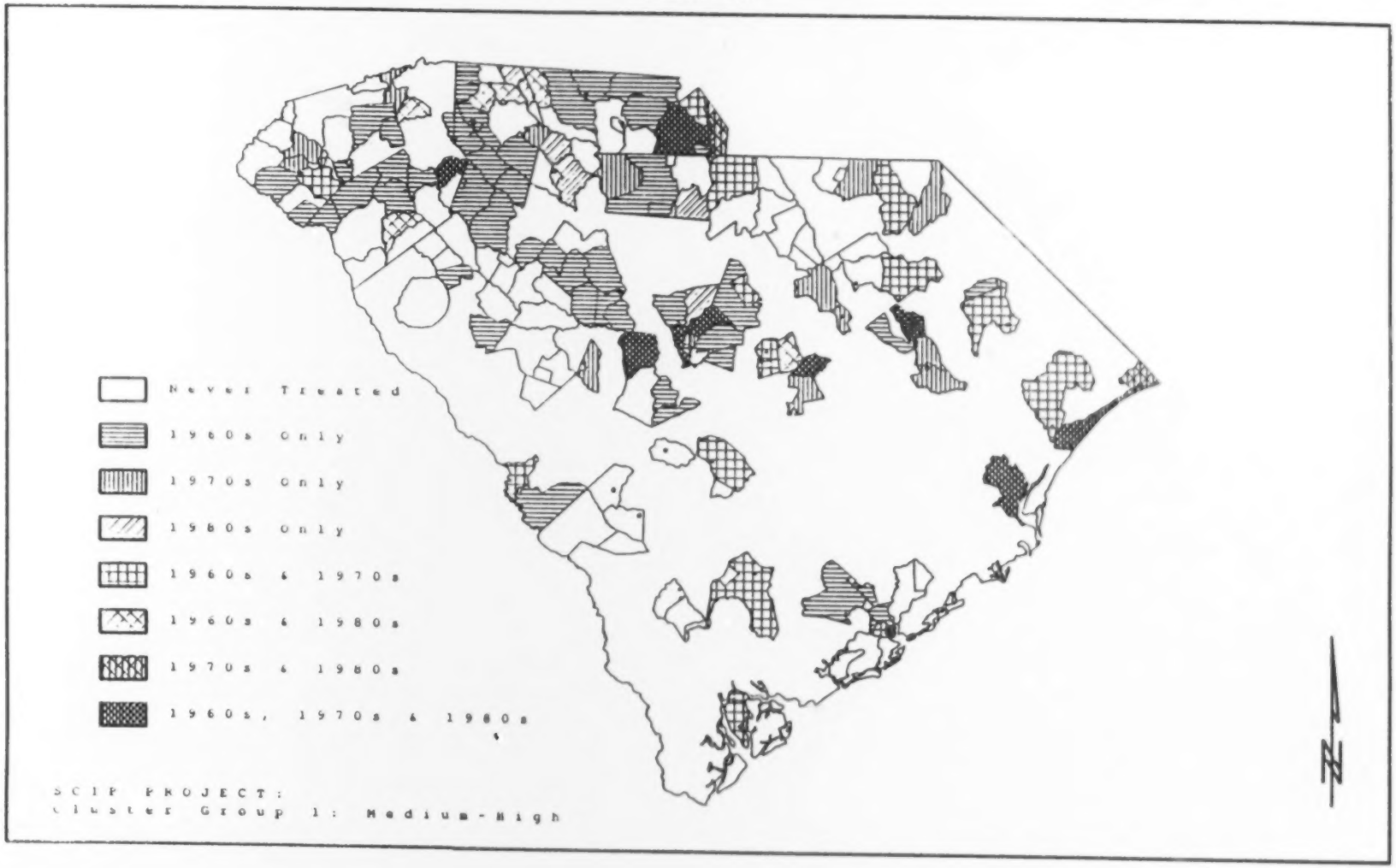
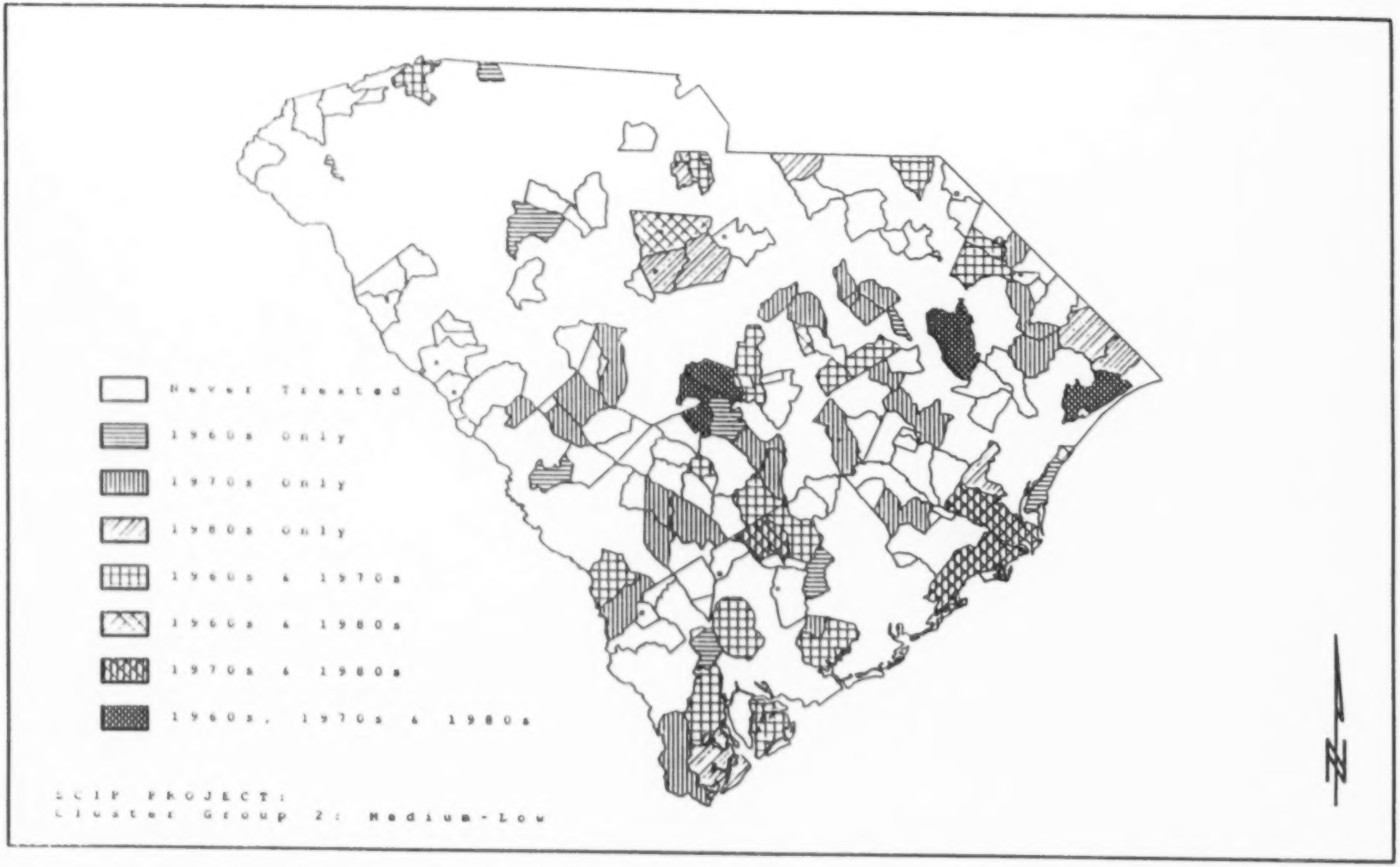

Never Treated
1960s Only
1970s Only
1980s Only
1960s & 1970s
1960s & 1980s
1970s & 1980s
1960s, 1970s & 1980s
SCIP PROJECT:
Cluster Group 1: Medium-High

FIGURE 4B


Never Treated
1960s Only
1970s Only
1980s Only
1960s & 1970s
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1960s, 1970s & 1980s
SCIP PROJECT:
Cluster Group 2: Medium-Low

54

FIGURE 4C

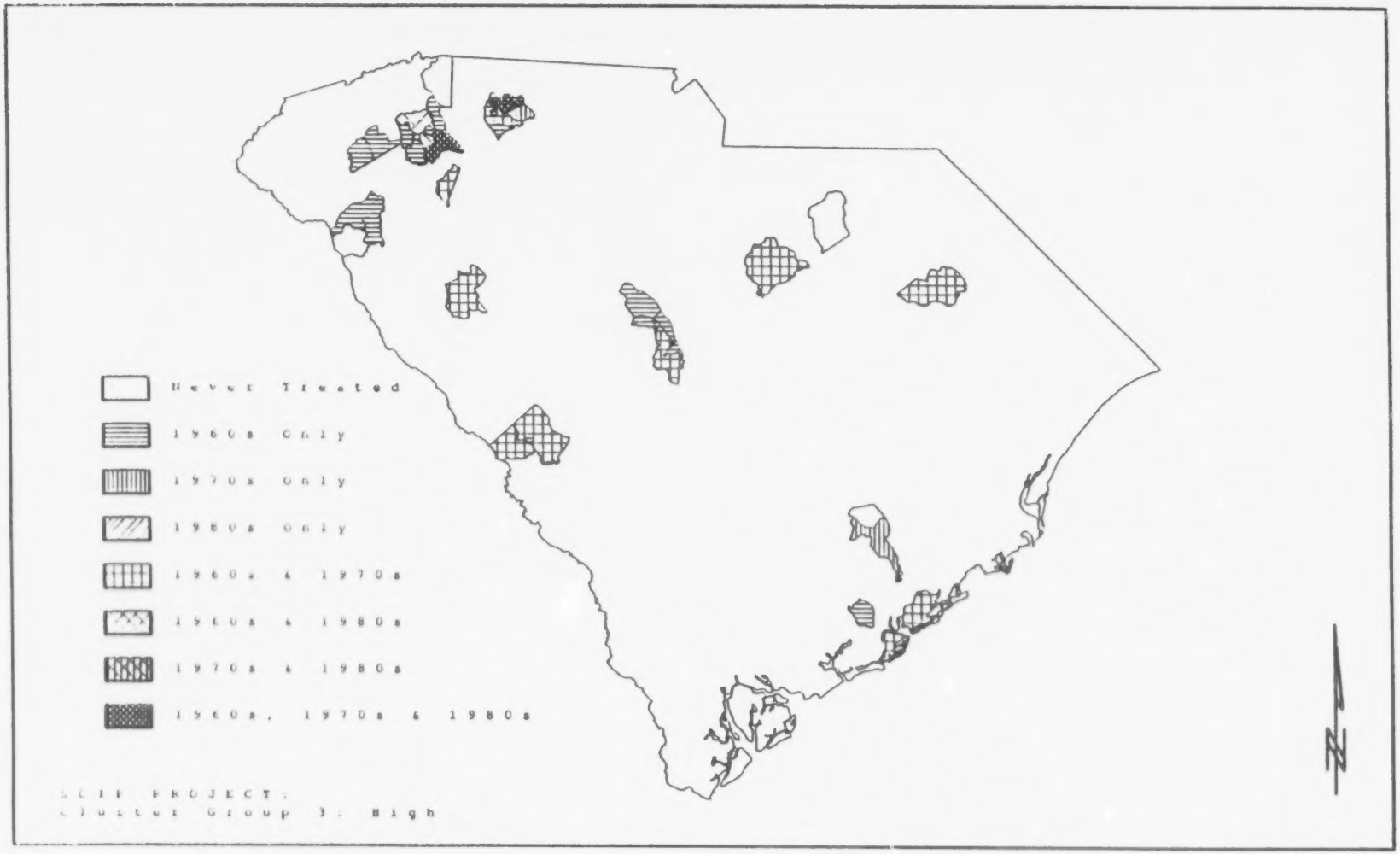
Never Treated
1960s Only
1970s Only
1980s Only
1960s & 1970s
1960s & 1980s
1970s & 1980s
1960s, 1970s & 1980s
SCIP PROJECT:
Cluster Group 3: High

FIGURE 4D

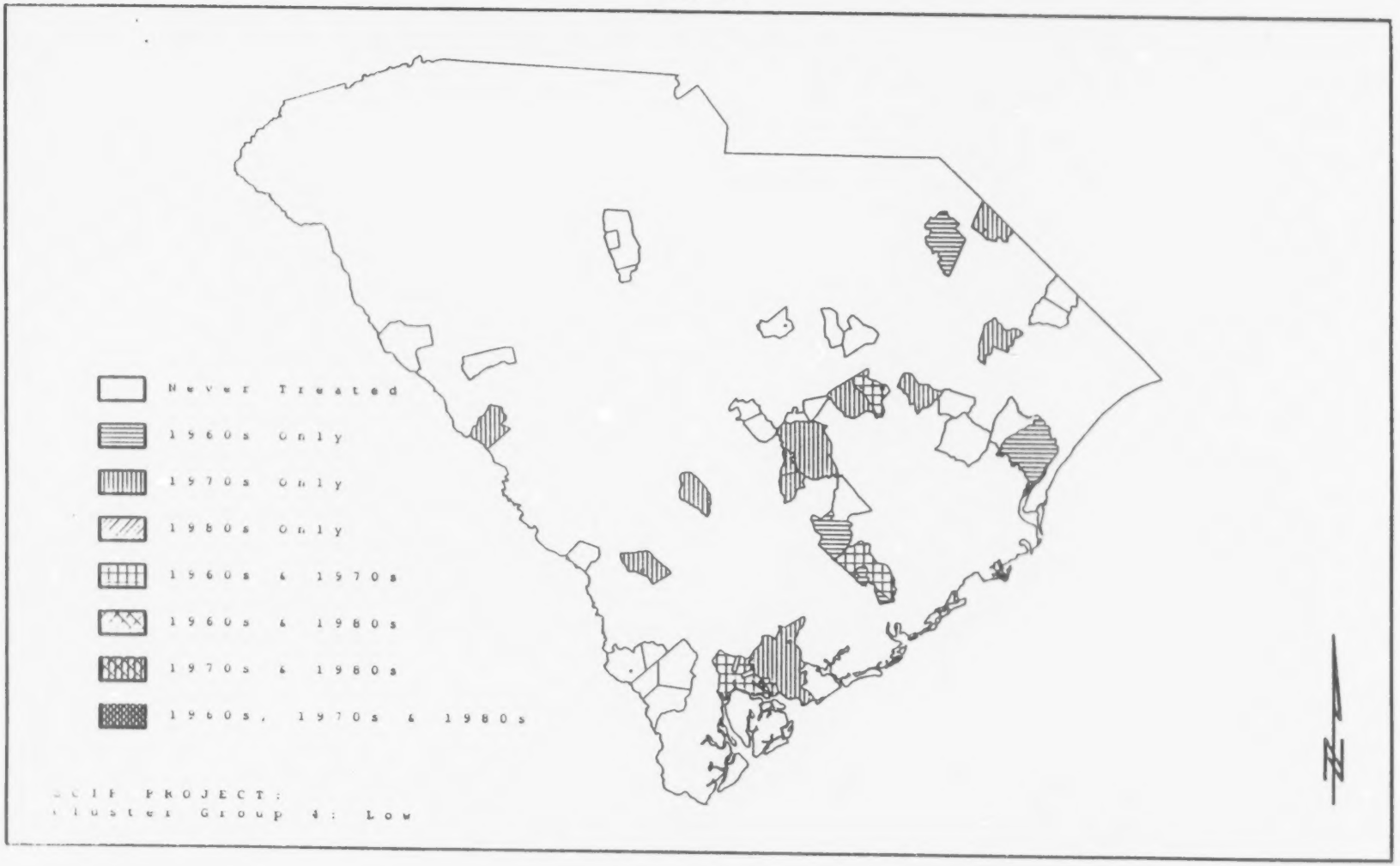
Never Treated
1960s Only
1970s Only
1980s Only
1960s & 1970s
1960s & 1980s
1970s & 1980s
1960s, 1970s & 1980s
SCIP PROJECT:
Cluster Group 4: Low

FIGURE 5

THE LOWCOUNTRY REGION

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Working Paper

Education: Linkages with Economic Development

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University of Florida

INTRODUCTION

The commission given for this paper by the Southern Regional Information Exchange Group (SRIEG-53) was simple and uncomplicated: survey the literature to determine research linkages between education (human capital) and economic development, and consider potential researchable topics between the two subject areas. Although the charge by SRIEG-53 seemed elementary, accomplishing the directives proved more difficult. In summary, the literature revealed very limited research linkages between human capital and economic development. Many economic development studies have been conducted in developing countries, especially Africa and Asia. On a more positive note, the lack of documented research linkages between human capital and economic development implies that research opportunities will be unbounded.

LITERATURE REVIEW

Economic Development

Research interest in the topic of economic development is immense. A general search under the subject heading in the University of Florida library system yielded almost 2400 manuscripts on the topic, excluding periodicals. As mentioned previously, much of the research was concentrated in the developing areas of Africa and Asia.

A significant portion of the literature is case study based. These studies may prove most useful and insightful for the SRIEG-53 group. Many of the case studies concentrate on identifying factors that influence new business start-ups or expansion of businesses already present in communities. Factors identified that influence business location and expansion have been fairly consistent among studies in both the private and public sectors.

Determinants with positive influence on economic development include location, availability of labor, labor skills, quality of schools, access to doctors, hospitals, banks, and credit institutions (Southern Growth Policies Board, Wallace, Stark, Richards, Carlino and Mills, Hedman). Thrall identifies a different categorization of industrial location determinants that includes agglomeration economics, manufacturing costs, transportation costs, availability of resources, amenities and government. All the previously identified determinants could be cataloged under Thrall's system. The National Association of Towns and Townships identifies capital, labor and technology as necessary factors for business formation.

Research also suggests that economic activity as measured through plant location deviates based on other factors. For example, Hekman noted that industrial location determinants vary according to firm size. Specifically, he noted small firms have a "much narrower focus for site selection than large companies with plants in several states. Most of the small firms consider sites in only one state...usually close to the owner's place of residence" (Hekman). Epping concluded that "traditional" industries base plant location and relocation decisions primarily on labor supply and raw materials and all other factors are

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secondary determinants. His research further notes that the availability of the labor supply in the community where the firm locates is less important than the availability of the labor supply in the area where the firm locates. Obviously this refers to the willingness of labor to commute for employment opportunities.

Buck and Hobbs conducted a study to determine location determinants of new high technology firms. The study was limited to 57 university and college communities across the country. One of the important determinants identified was expected: the presence of a "major" research oriented university influenced the firm's location. Another important determinant was less expected: the chief executive officer in a "majority of firms was either an alumnus or a former faculty member of the local university." This later finding may be cited as the California model. Individuals familiar with the development of the "Silicone Valley" in California are well aware that most high tech companies in the region were started by university faculty, graduate students or undergraduates from one of the colleges in the immediate vicinity.

Buck and Hobbs asked the high tech firms surveyed to identify and rank 56 factors that were important to firm location. Factors identified as essential or very important were a clean physical environment, availability of technical personnel, absence of drug/alcohol problems in the community, quality school system, low traffic congestion, knowledgeable bankers, positive government policies toward industry, and availability of medical facilities and services.

Less important determinants were industrial site leases, wage levels, vocational training facilities, trucking and rail service, waste disposal, water system capacity, public transportation and private schools. Buck and Hobbs noted that Southern firms in general expressed similar opinions to all firms but placed more emphasis on vocational training, climate, business tax advantages, cost of living, availability of industrial sites, proximity of machine shops, etc. Location determinants of less importance to businesses in general identified by Carlino and Mills include taxes, community attitudes, state/local legislation and industrial development bonds.

These studies contribute much to our understanding of firm location decisions. However, more information needs to be assimilated to fully understand firm decision choices. For example, do location determinants vary according to size of the firm as suggested by Hekman? Are there regional differences as suggested by Buck and Hobbs? Most of the case studies concentrate on survey information. Can these data be quantified to increase our understanding of firm location decisions?

Education and Human Capital

Educational studies are also a robust body of research. Although the sheer number of studies is not as large and diversified as research in economic development, the majority of educational research can be ordered in one of the following classifications: finance, administration, curriculum and methods. Economic aspects of education comprise only a very small proportion of educational studies and there appeared to be no strong links between education and economic development, at least in quantified techniques.

Three of the categories of educational research, administration, curriculum and methods, are self-explanatory. Administration research typically covers topics related to overall school administration from a superintendent and guidance perspective. Curriculum research, in layman terms, concentrates on developing the core classes needed by students to succeed in the world of adults. Methods research appears to concentrate on how teachers take knowledge, transfer it to students and help them learn.

Economic contributions to educational research are more limited and narrow in scope. In general, the primary contributions have been in school financing and more specifically concentrate on equity issues associated with school funding. Economists share this research effort with educational finance experts. Berne and Steifel identified in excess of 50 educational finance studies that address school funding

issues on an equity basis. In most instances these studies concentrate on school distribution formulas and assess how these formulas contribute to a non-equitable distribution of funds, or how the formulas could be altered or improved to provide for a more equitable distribution of funds.

Agricultural economists contributed modestly to educational research in the 1970s (some names appearing in the literature search include Stinson, Debertin, Tweeten, Huie and Clouser). Contributions appear to have declined in the 1980s except for a small quantity of work by Deaton and McNamara at Virginia Polytechnical Institute and State University. Unlike the administration, curriculum and methods body of educational research, economic research appears more quantifiable. For example, contributions of the above mentioned authors attempt to quantify differences in funding between rural and urban areas, economies of school size, drop-out rates and school and non-school educational inputs.

At least among agricultural economists, education research topics appear to be in a renaissance period. Increased interest in the topic seems to be closely linked with escalated interest in rural development (Deaton, Drabenstott et. al, Knutson and Fisher, Schertz, Swanson and Butler, Rosenfeld, Clouser, etc.). The concern expressed about educational issues by these authors does not appear to have been translated into quantifiable research output. Maybe enough time has not passed since the issue has come into vogue again for necessary studies to be published. However, at the present time agricultural economic contributions to educational and human capital research is built more on ideas and questions rather than empirical work. Some change can be expected in the short-term, at least in the south, since individuals in Virginia, Florida and Kentucky are working on educational research or extension studies.

The economic literature review did not establish a strong research linkage between education or human capital and economic development. Some subsidiary linkages were evident though. For example, research exists that addresses returns to investment in education and research (e.g. Ayer and Schuh, Griliches, etc.). This mass of research typically demonstrates that for every dollar invested in education and research, that dollar plus an additional amount accrues to the public. Similar frontier research on human capital has been put forth by Schultz and Becker. Most are familiar with Becker's theory of investing in human capital, which concluded that "some persons may earn more than others simply because they invest more in themselves." This increased investment can be accomplished by individuals through schooling, job training, improved medical care, etc. Becker further asserted these investments raised earnings as the individual aged and reduced earnings at younger ages because the cost of investing is deducted from earnings at that point in time.

RESEARCH TOPICS

The literature review indicates that opportunities for research related to linkages between education/human capital and economic development should be bountiful. The question still remains, though, where do researchers begin? As a starting point to address this question it is suggested the report by the Commission on the Future of the South, "Halfway Home and a Long Way to Go," be utilized. The Southern Growth Policies Board that commissioned this study is composed of state government leaders from the south, and while their judgment on issues may be clouded by politics at any given point in time, the board and commission appointed to explore issues represents a broad consortium to identify pertinent public issues.

One of the Commission's first recommendations was that southern states provide nationally competitive education for students by 1992. The commission noted that southern states had made a large commitment to education since 1983, but they also noted that southern states started earlier than most other states. Although they do not specify exactly how this goal might be accomplished, they do delineate some potential research ideas. One possible topic would be educational finance.

How do states raise money required to provide desired educational levels when property tax wealth and incomes are extremely low in many southern states, especially in rural areas? A second possible research topic under this recommendation would deal with teaching methods or a more common jargon used today might be learning styles. Sociologists may be more comfortable with this topic than economists. However, economists can contribute to research in this area especially if it is linked to economic development. The case study presented by the school superintendent of Forrest County, Mississippi, at the Birmingham Infrastructure Conference in May 1990 is a good example. Teaching methods or learning styles were altered through use of a "gold card" that both improved grades and increased community economic activity at a total cost to the community of about $1500.

Another possible research topic under this general recommendation is a better understanding of the dropout dilemma from both an economic and social perspective. It might prove useful to conduct research to determine if economic incentives can be used to prevent dropouts or if economic incentives (e.g., businesses that hire without requiring a high school diploma) contribute to the drop-out rate. It also seems appropriate to address concerns about school and non-school based inputs and the contribution of these inputs to education (Clouser and Debertin, McNamara).

A second need identified by the Commission was the mobilization of resources to eliminate adult illiteracy. Obviously the Commission was thinking about financial and human resources. However, it seem that social scientists should be able to contribute to a better understanding of this problem through their knowledge of institution building. How do you encourage those who can't read to participate in programs? Through what type of institutions are programs offered -- community colleges, universities, extension service -- and what type of institutions will be most effective and economical?

Research opportunities exist in a third area identified by the Commission: preparation of a globally competitive work force. It is under this goal that the committee decided to address issues related to vocational training. Perhaps this concept needs to be broadened to life long training, or what Deaton refers to as work related education (WRE). Necessary work skills have changed dramatically in the last decade. Equally rapid change can be expected in the future. Training of only school age individuals will not provide for a skilled work-force. How do states accomplish this goal? Again, social science contributions to this issue may concentrate on institutional issues (how do we build or mobilize an institution to respond to this problem)? At the same time issues related to teaching methods and learning styles of an older target population will need to be addressed. This may represent an appropriate area to employ Becker's theory of human capital investment.

One other goal of the Commission explicitly relates to education: increase the economic development role of higher education. The link recommended by the Commission with higher education seems narrow and short-sighted. It leads one to assume the Commission looks to higher education as an industrial recruitment arm of state and local government. Though not explicitly stated as such in the Commission's report, there is evidence that at least one southern state views the role of higher education as industrial recruitment (with one major responsibility being business and job expansion). A case can be made for increased emphasis on economic development by higher education. However, by concentrating on that single issue the potential increases for other high priority research topics to be ignored.

What are some of the other possible research issues related to education and economic development? No evidence was found in the literature of linkages between current investment in human capital and education, possible economic payoffs and time. Can anyone answer the question: if an investment of dollars is made in education today how long until communities begin to reap gains from the investment? Maybe the researchable issue is if communities make an investment in education will they reap any gain at all, or do gains accrue to other communities because of

increased mobility of the newly trained individual? If gains accrue to other areas due to training mobility, does this indicate need for changes in federal programs to compensate areas that provide funding? The issue of education and economic development seems to lead to a list of endless questions. Questions that, for the most part, seem unanswered.

DEFINING INTENT

A difficult task remains for this particular information exchange group and the regional research project the group hopes eventually to bring to fruition. How can the group set priorities with potential research issues? A second related concern is the availability of funding to undertake research projects.

The information exchange group has cleared the first hurdle; there seems to be little disagreement among the group in defining infrastructure. The accepted definition includes more than "brick and mortar" infrastructure. Some clarification may be necessary among the group in defining economic development. Does economic development imply increased income and jobs, or is a broader definition that would include outcomes such as improved government efficiency acceptable? Assuming this definition hurdle is dealt with, where do educational issues rank in an overall priority list?

Data vary across the country, but somewhere in the neighborhood of 45 to 60 percent of state general fund revenue is used to finance secondary education. From a state perspective, especially in monetary terms, education may be the top priority. Prior emphasis on educational issues from a national perspective would indicate a lower priority ranking. This may have occurred because most federal dollars allocated to support education were compensatory and allocated for very narrow programs (e.g., handicapped programs). However, the recent summit with the nation's governors and the President appears to have raised the issue higher on the priority list.

In order to conduct educational research programs, monetary resources are required. Are funds available or can individuals interested in this research area compete for those funds? Social scientists may be at a disadvantage in attracting necessary funding dollars. There may be an even greater disadvantage for individuals at land grant institutions who have specialized in attracting money and establishing institutional relationships in agricultural production, marketing and management.

SUMMARY

Opportunities for human capital and economic development research exist. However, many barriers still must be overcome. As the information exchange group discusses a broad range of possible research topics, it must be determined if the group has a comparative advantage in addressing particular researchable issues. That question remains largely unanswered in educational research.

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